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ORIGINAL ARTICLES.

I.—The Species of *Cidaris* from the Lower Greensand of Faringdon.

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(PLATES XXV AND XXVI.)

1. Introduction.

Of the varied Echinoid fauna from the well-known 'Sponge-gravels' of Faringdon, Berkshire, there are no constituent forms of which the remains are more abundant than those of *Cidaris*. It is no exaggeration to say that every handful of the 'gravel' will include many fragments of radioles, and some portions of test, which can be ascribed to that comprehensive genus.

The radioles seem to have been known to Llhwyd, although his mention of a "spine from Faringdon" may possibly refer to *Paracidaris florigemma* from the Corallian of the neighbourhood. It is, however, curious to find that, apart from references in lists of fossils found at the locality, these remains have been systematically discussed only by Wright (1868) in the monograph of *British Cretaceous Echinoidea*. In that work the species *C. faringdonensis* was first described, but the description and figures given were quite inadequate. This paper is an amplification of his description, based on very large quantities of material.

2. The name *C. faringdonensis*.

Wright spelt the specific name with a double *r*. It is true that on some old maps of Berkshire the name had this spelling, but long before 1864 it became usual to write it with the single *r*. I therefore prefer to follow Phillips, who in 1871 first changed the spelling to correspond with that of the name of the town.

As early as 1854 Sharpe (Q.J.G.S., vol. x, p. 194) remarked on the existence of more than one species of *Cidaris* in the Faringdon deposits, but until recently *C. faringdonensis* has been the only one recognized by name. In the report of an excursion of the Geologists' Association in 1909, Treacher gives a provisional identification of the radioles of the second type to *C. pretiosa*, Desor. Radioles of the same type are similarly labelled in the South Kensington Museum, but up to the present time no test fragments have been associated with them.

Having accumulated, largely owing to the constant help and encouragement of my friend Mr. Ll. Treacher, many hundreds of specimens of *Cidaris*-remains from Faringdon, I have been able to make an exhaustive comparative study of both types. There seem to be not more than two species of *Cidaris* represented among the very numerous fragments that I have seen, each species showing two fairly parallel varieties. (No account is taken in the present paper of the not infrequent waterworn radioles of *Paracidaris florigemma*, which have obviously been derived from the Corallian of the neighbourhood.)

I have examined Wright's type-specimens of *C. faringdonensis*, which are in the Museum of Practical Geology at Jermyn Street, and can confidently state that both the plates figured in the monograph (1864) belong to the same species. This is a contrary conclusion to that reached by Lambert (1892), but certainly, from a study of the figures alone, their reference to distinct species was justifiable.

Unfortunately the Cidarids of the 'Sponge-gravels' are almost always found in a disarticulated condition, and in no cases have the primary radioles and their tests been discovered in even probable association. Now the features of the radioles were well described and figured by Wright, while the treatment of the plates of the test was short and inconclusive. Judging by this fact alone, it would seem expedient to regard the species *C. faringdonensis* as having been founded on the radioles, in case it should be determined that the plates and radioles figured under that name belong to different species. Fortunately, in this case, there seems no doubt but that the plates of the type he figures on pl. ii, figs. 6 and 7 of the monograph, do in reality belong to the same species as the radioles of fig. 8. I have counted the actual numbers (of recognizable specimens) of plates and radioles of over a thousand specimens of both the types present at Faringdon, and find that the series corresponding with Wright's figures are almost twice as numerous as those of the second species. Adding to this the consideration that the average size of plates and radioles of the already figured types is much greater than that of the other forms, it seems to be a safe assertion that *C. faringdonensis*, Wright, is a valid species, of which both the test and radioles are known.

Of the other type, not without great hesitation, I have made a new species, the characters of which, as will be found in the description, are much more satisfactorily known than are those of *C. faringdonensis*.

3. Species that have been ascribed to *C. faringdonensis*.

In 1873 de Loriol, in the *Échinologie Helvétique*, p. 51, pl. iii, figs. 31–5, announced the discovery of *C. faringdonensis* for the first time out of England. Judging from his remarks, he seems to have referred only to Wright's description and figures in making the specific determination. The specimens he described are a broken test and some very fragmentary radioles. The latter certainly bear a considerable resemblance to the radioles of Wright's figures, although, as de Loriol himself observed, their collerettes are comparatively

short. But when the description and figure of the Swiss test are compared with specimens of the true *C. faringdonensis* very obvious differences between the forms become apparent. One of the most readily recognized distinctions lies in the form of the test. Although not more than four plates of *C. faringdonensis* have been found connected together, all the evidence points to its having been large and tall, perhaps pyriform. De Loriol's specimen is quite small, and remarkably compressed at both poles. The existence of from five to six rows of granules in the widest parts of the ambulacra in the Swiss specimen finds no counterpart in even the largest examples from Faringdon. Although the absence or presence of crenelations on the interambulacral tubercles has little systematic value, yet the almost perfect smoothness of the platforms and parapets in de Loriol's specimen, and the persistent, and often very apparent, crenelation found in the species of the 'Sponge-gravel', lend a fresh point of contrast between the two forms. The 'granules très fins' of the scrobicular ring in the Swiss form do not correspond with the exceptionally large and spaced-out secondary tubercles from that region in *C. faringdonensis*, while a similar difference is found in the coarseness of the miliary granulation. On these grounds I feel confident that the *C. faringdonensis* of de Loriol is a distinct species from the *C. faringdonensis* of Wright, and should no longer bear the same name.

Almost twenty years later Lambert (Bull. Soc. géol. France, sér. III, tom xx, p. 39), describing the Echinoid fauna of the Aptien of Grandpré, refers a Cidarid from that locality to *C. faringdonensis*; or rather, to the same species as that described by de Loriol. In the latter identification he would seem to have been correct, as his figures and descriptions agree in all essentials with those of de Loriol. It is, therefore, unnecessary to repeat the reasons that cause me to distinguish his species from the true *C. faringdonensis*. As a result of his study of the test-structure, Lambert doubtfully referred his species to *Goniocidaris*. Of the expediency or otherwise of this generic determination there is no need to inquire here, save to remark that sutural pits of the kind found in his species are well marked in many Oolitic (e.g. *C. marginata*, Goldf.) and Cretaceous (e.g. *C. sceptrifera*, Mant.) species. But there is not the slightest trace of such pits in the test fragments of *C. faringdonensis* from the typical locality, a fact which again emphasizes the difference between the two forms.

For this species, the *C. faringdonensis* of de Loriol (1873) and the *Goniocidaris faringdonensis* of Lambert (1892), I propose the name '*Cidaris*' *testiplana*, nom. nov., in reference to the extreme flattening of its test.

The only other reference of a fossil to *C. faringdonensis*, apart from stratigraphical lists, is that by Stolitzka (1873) in the *Palæontographica Indica*. Two very small fragments of poorly preserved radioles are doubtfully referred to this species. Since the descriptions and figures are as obscure as the specimens themselves, it is impossible to speak definitely as to the correctness of the determination. On prima facie evidence, it would be very exceptional for a species

that characterizes a local deposit in England to occur also in India, and I am inclined to agree with Lambert (1892) that the identification is incorrect.

(PLATE XXV.)

4. Redescription of *C. faringdonensis*, Wright.

After these discussions it is possible to proceed to the diagnosis and description of Wright's species, followed by a similar treatment of the second type of Faringdon *Cidaris*. The synonymic list for the former includes all the references of a probably correct nature that I have been able to find.

Cidaris faringdonensis, Wright (1864), 1868.

Synonymy.

	1854.	*Cidaris* sp.,	Sharpe, Quart. Journ. Geol. Soc., vol. x, p. 194.
	1858.	*C. coronatus*,	Etheridge, Geol. Surv. Mem., Sheet 34, p. 32.
	1861.	*Cidaris* sp.,	Etheridge.
	1864.	[*C. farringdonensis*],	Wright, Brit. Cret. Ech., Palæont. Soc., vol. i, pt. i, pl. ii, figs. 6–8.
	1868.	*C. farringdonensis*,	Wright, loc. cit., pt. ii, pp. 68, 69.
	1871.	*C. faringdonensis*,	Phillips, Geol. Oxford, p. 433, pl. xvii, fig. 5.
	1874.	*C.* ,,	Davey, The Sponge Gravels of Faringdon.
	1875.	*C.* ,,	Quenstedt, Petref. Deutsch., Echiniden, p. 179.
	1877.	*C.* ,,	Davey, Cat. Foss. Cret. Berkshire.
	1878.	*C.* cf. ,,	Barrois, Mém. Terr. crét. Ardennes.
	1883.	*C.* ,,	Keeping, Fossils of Upware, p. 135.
	1900.	*C.* ,,	Hesse, N. Jahrb. Min., Beil. Bd., xiii, p. 235.
	1905.	*C.* ,,	Davey, Neocom. foss. Faringdon, p. 31.
	1909.	*C.* ,,	Treacher, Proc. Geol. Assoc., vol. xxi, p. 119.
?	1863.	*C. salevensis*,	'Desor,' De Loriol, Néocom. moy. Mont. Salève.
Non	1873.	*C. farringdonensis*,	De Loriol, Ech. Helvét., pt. ii, p. 51, pl. iii, figs. 31–5.
Nec	1873.	*C. farringdonensis*,	Stolitzka, Pal. Indica, Cret. Fauna, iv, p. 49, pl. vii, figs. 29, 30.
Nec	1892.	*Goniocidaris farringdonensis*,	Lambert, Bull. Soc. géol. France, sér. III, vol. xx, p. 39, pl. ii, figs. 3–12.

Diagnosis: Test, var. *typica*, nov.—Form unknown, probably large and considerably elevated. Ambulacra about one-sixth the width of the interambulacra, with two perradiad rows of prominent granules which rarely, even at the ambitus, enclose scattered smaller granules. Interambulacral plates thick; scrobicules circular, covering most of the plate-surface; bosses wholly or partially crenelated; mamelons large, perforated. Scrobicular circle of (usually thirteen) prominent secondary tubercles, separated by spaces wider than their diameters; with an outer, alternating, ring of tertiaries. Miliaries coarse, often only present towards the plate-angles.

Var. *maxima*, nov.—Similar to var. *typica*, but always of large size, with broad interambulacral miliary zones, in which the miliaries are closely packed, without apparent order.

Radioles.— Exceedingly long, cylindrical. Stem covered with longitudinal rows of small, partially confluent granules, of which alternate rows persist to the distal end, become carinate, and terminate in a slight corolla. Subsidiary granule rows often appear between

the main series. Collerette long, often one-third the length of the radiole, smooth, and separated from the stem by a prominent, slightly oblique 'bourrelet'. Annulus prominent, base strongly developed. Acetabulum deep, with a crenelated margin and large central perforation.

Description: General Characters.—Except in a few cases all the portions of the test have been separated (often being waterworn), so that an accurate idea of the form of the urchin cannot be obtained. Judging from the very slight curvature of four associated plates of one column, and from the large dimensions of plates from the adapical part of the test, it may be inferred that the whole body was large and tall, perhaps somewhat pyriform. The diagnosis and description of the plates are generalized from over four hundred specimens, and of the radioles from nearly six hundred. The examples chosen for figuring show average types, among which may be included Wright's original figures.

The Apical System.—The genital plates (Pl. XXV, Fig. 10) are almost square in outline, the specimen figured measuring 4 mm. along the periproctal and radial margins. The thickness increases from the periproctal edge adorally, and at the coronal margin the plates are abruptly truncated. The genital pores are large and circular, placed at a distance of about one-quarter the radial diameter of the plates from the coronal edge. They pass obliquely through the plates, emerging in a slight concavity near the centre of their inner surfaces. The external ornament of the plates consists of granules on a shagreened surface. One row of granules, larger than the others, forms a rim between the genital pore and the coronal margin, while the rest are engaged in close-set lines, which tend to radiate from a point to one side of the pore. The plate-surfaces become smooth towards the edges, especially that which borders on the periproct.

The ocular plates (Pl. XXV, Fig. 11) are similar to the genital ones, except in shape. They are elongated transversely, and are strongly concave along the periproctal margin, being convexly rounded at the coronal edge. They too show a loss of ornament near the periproct.

The Corona: Interambulacral Plates.—Average-sized plates from the adapical surface of the test measure about 13·5 mm. longitudinally and about 10 mm. along the adoral transverse margin. The plates are constantly taller than broad, sharply incurved at the adapical end, scarcely curved in section in the other parts. The adapical transverse margin is a little inclined towards the interradial suture, and slightly concave. The adapical oblique margin is concave to a less degree, but the other three edges are sensibly convex. The adradial margin is strongly curved, concave adapically, but convex (concentrically with the scrobicular ring) in the middle and adoral parts. It is furrowed on the adradial surface by about twenty-four grooves. The scrobicule is wide, circular, slightly excavated, and situated towards the adoral region of the plate, near to the adradial margin. There is a definite basal terrace at about two-fifths the radial distance from the ring. The boss is central, rising like a dome to a platform of a diameter one-third that of the scrobicule. The platform is very slightly

excavate, with a low parapet, which is in part rendered granular in appearance by more or less deep crenelations. There are about eighteen crenelations on the platform. The mamelon is large and prominent (diameter about 1 mm. less than that of the parapet), circular, with an undercut neck and deep central perforation. The scrobicular circle is complete, surmounted by a ring of from twelve to fourteen (usually thirteen) secondary tubercles. Their mamelons are about 1·5 mm. apart when their diameters are 1 mm. The diameter of a secondary may be as much as half that of the primary mamelon. The bosses of the tubercles are elliptical in shape, adjacent tubercles being contiguous in the direction of their long axes. Outside the scrobicular ring is a complete cycle of tertiaries, alternating regularly with the secondaries. (In small examples the tertiaries are without mamelons, but are always larger than the miliaries.) They are oval in shape, the pointed part encroaching a little into the scrobicular ring. They are usually less than half the size of the secondaries. Outside the tertiaries there appear, in very large specimens of var. *maxima*, traces of an intermittent ring of quaternaries, but these are not often distinguishable. The miliaries are closely packed, and diminish very little in size when traced to the margins of the plate. There are usually no miliaries between the scrobicular ring and the adradial and adoral margins of plates of var. *typica*. The granules are circular in plan, and somewhat flattened. They are always without any visible order of arrangement.

In some of the largest specimens (var. *maxima*), when an adapical plate may be as much as 27 mm. in transverse measurement, the miliaries are proportionately more numerous than on average-sized examples.

An interesting abnormality in a plate from this region is shown in Pl. XXV, Fig 13. It will be noticed that the scrobicular ring is double, the accessory circlet of secondaries being inside the normal series and somewhat inclined towards the boss. There are thirteen tubercles in the normal cycle, and sixteen in the inner, accessory ring.

Plates from near the ambitus are often almost twice as broad as high, but otherwise differ hardly at all from those of the higher cycles. The crenelation of the platform is usually less pronounced. Both var. *typica* and var. *maxima* are as recognizable in this part of the test as in the others. Measurements of an average ambital plate of var. *typica* are: height 6·6, breadth 11·4 mm.

Towards the peristome the plates become almost square, so that the interradial suture will have been nearly straight. In rare cases the scrobicule tends to become elliptical, but it is usually circular. There are very few miliaries left on the plates near the peristome, even in var. *maxima*. It is of interest to note that two or three adoral interambulacrals are not frequently found in connexion. This is probably due to a more complete union along the sutures due to the pressure of the newly formed plates. The proximal adoral plate may show varying stages of resorption, the inward bevelling often commencing across a tubercle. The auricles are too much waterworn in all the specimens available to be worthy of description.

Ambulacral Plates.—There are, on the average, twenty-four simple primaries to each interambulacral. The pore-pairs are almost horizontal at the adapical end of the ambulacra, in deeply sunken poriferous zones, and become slightly inclined towards the perradial suture for most of their course. The pores are practically circular, and encircled by a faint peripodium. The pores of each pair are separated by a prominent granule of rather greater diameter than the pores themselves. Along the perradial part of the ambulacra high ridges of prominent granules, one granule to a plate, pass the entire length of the areas, and, except in very large specimens of var. *maxima*, occupy the extreme perradiad portions of the plates. In these large examples, near the ambitus, traces of irregular and quite minute granules occur, but these never reach half the size of the granules of the main series. The horizontal measurement of one ambulacral plate is about 2 mm., of which 1·2 mm. are occupied by the poriferous zone. Thus the total width of the ambulacrum is about 4 mm.—roughly one-sixth that of the interambulacrum.

Primary Radioles.—These radioles vary considerably in size, the largest obtained being 61 mm. in length and 4·25 mm. in breadth (some fragments indicate even larger size), while an average specimen gives corresponding measurements of 40 and 4 mm. The stem is cylindrical, never appreciably inflated, and covered with regular granular ridges. The space between the ridges is finely shagreened. The distal end of the stem is often slightly expanded, and alternate ridges, becoming carinate, develop into a stellate corolla of small size. The collerette is very long (the proportion varying but slightly with the length of the radiole), the average measurement being about 10 mm. Its diameter is very slightly less than that of the stem, and its surface is smooth. The 'bourrelet' which separates it from the stem is well marked, cylindrical, and almost at right angles to the axis of the radiole. The annulus is apparently smooth and not prominent. The base is inflated to about 1·5 times the diameter of the collerette, but the acetabular ring (which is often crenelated) forms a circle of diameter equal to that of the bourrelet. The acetabulum is deep, with a wide central perforation. Some radioles show a diminution in the diameter of the collerette near the bourrelet, making the proximal end of the radiole broader than the rest.

There are three or four large radioles in Mr. Treacher's collection which are smooth and tapering (Pl. XXV, Fig. 14*g*). I regard these as variants of *C. faringdonensis*. I have a specimen of *C. sceptrifera*, Mant., from the Upper Chalk, which has attached to it many normal denticulate radioles and several devoid of ornament; the smooth radioles from Faringdon seem analogous. They can be easily distinguished from radioles of *Pseudodiadema*, with which they are associated, by their greater proportionate breadth and general size. Some intermediate stages show faint traces of the typical *faringdonensis* granulation (cf. Pl. XXV, Fig. 14*a*).

Secondary Radioles.—I ascribe the larger secondary *Cidaris* radioles from Faringdon to this species. They are small and flattened, averaging 4 mm. in length and 1 mm. in breadth at the base. Their

shape is that of a very acute isosceles triangle. At the abruptly truncated base is a shallow acetabulum. The convex (outer) side of the radiole is covered with fine, slightly granular lines (about seven in average specimens). The flat (inner) surface is quite smooth.

Comparison with other species.—The outstanding features of the test of *C. faringdonensis* are its great size, the coarse crenelation of the primary tubercles, the large size, but slight prominence, of the scrobicular tubercles, and the paucity and coarseness of the miliary granules. The characteristic features of the radioles are their length, the great development of their collerettes (and their separation from the stem by a bourrelet), and the faint corollæ at the distal ends. The distinction between this and the associated species will be dealt with after the description of that form. Apart from the species already discussed, there remains only one type with which comparison may be useful. The simple ambulacral granulation serves to distinguish *C. faringdonensis* from most Neocomian and Cenomanian species.

C. vesiculosa, Goldf., with which Wright compared the species, has notably broad miliary zones. Except in var. *maxima*, the miliaries occupy a very small part of the interambulacral plates of *C. faringdonensis*. The scrobicules in the latter species are shallow, in the former they are deep.

In the case of the radioles the peculiarities of *C. faringdonensis* mark it off sharply from other forms, except from a radiole described by de Loriol in 1863 as *C. salevensis*, "Desor in notis," 1862. This seems almost identical with the Faringdon radioles, but, since only a broken radiole of *C. salevensis* is known, I have thought it inadvisable to certainly identify it with *C. faringdonensis*, especially as it would necessitate a change in the nomenclature. The recognition of species of *Cidaris* founded on the radioles alone is quite impracticable, and merely complicates the already overburdened synonymy of many species whose structure is well known.

Horizon and Localities.—Aptian (Lower Greensand) of Faringdon, Berks; also from Upware, Cambs (*fide* Keeping), and perhaps from the Ardennes (*fide* Barrois).

(PLATE XXVI.)

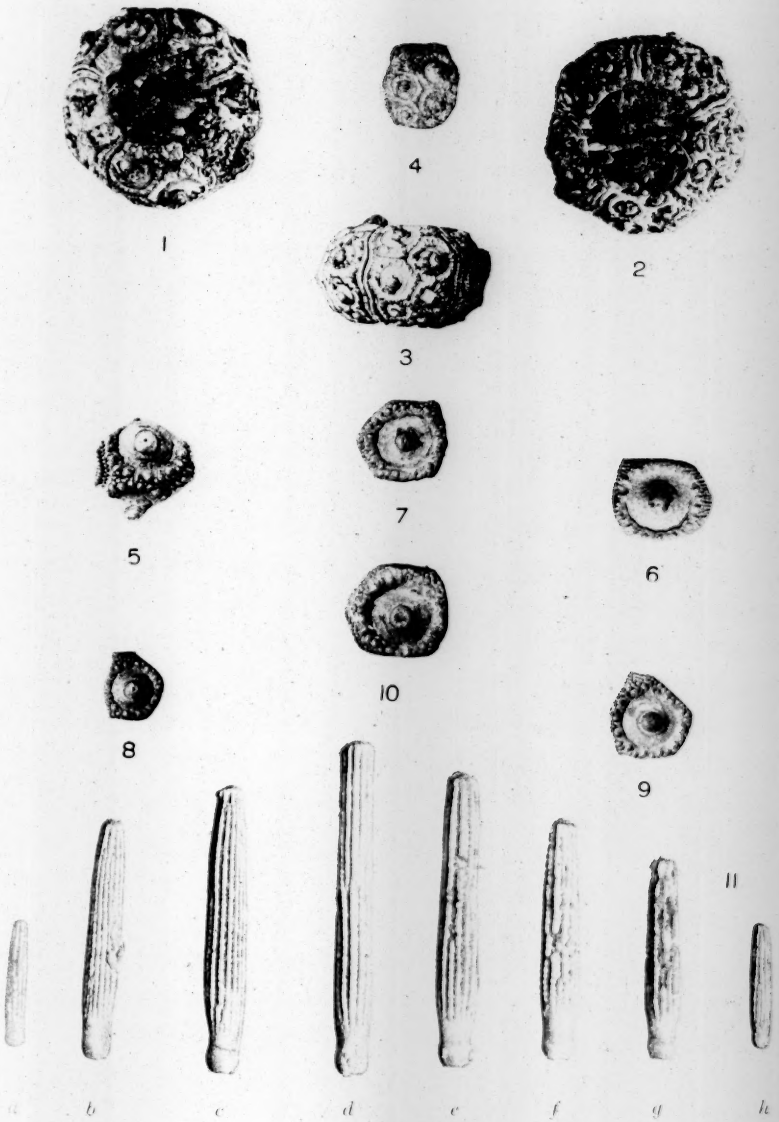
5. Description of the Second Species of Faringdon *Cidaris*, *Cidaris coxwellensis*, sp. nov.

(The 'Sponge-gravel' pits are near the village of Great Coxwell.)

Synonymy

1909. *Cidaris pretiosa*, Treacher (*non* Desor), Proc. Geol. Assoc., vol. xxi, p. 119.

Diagnosis: Test, var. *typica*, nov.—Form of medium size, fairly high, almost equally flattened adorally and adapically. Ambulacra about one-sixth the width of the interambulacra, with four rows of perradiad granules, the outer rows being the larger. Interambulacral plates thick, with obscure pits at the interradial angles and on the transverse sutures; scrobicules circular, bosses smooth, mamelons large, covering nearly all the platform, finely perforated. Scrobicular circle of very small, well-spaced secondary tubercles



Cidaris coxwellensis, Hawkins.

often joined to the scrobicular ring by a low ridge. Tertiary tubercles of almost equal size to the secondaries, alternating with them, and often intruding into their circle. Miliaries fine, rarely more than one row outside the tertiaries.

Var. *major*, nov.—Similar to var. *typica*, but constantly larger. Miliaries numerous, arranged in transverse series, separated by sulci on the ambital plates

Radioles.—Long, cylindrical, inflated on one side. Stem covered with coarse, partially confluent granules (most marked on the inflated side), which increase in size gradually from the collerette until, near the distal end, they fuse into carinæ, terminating in a pronounced corolla. Collerette short, undefined distally. Annulus prominent, base large. Acetabulum deep, with a smooth margin and large central perforation.

Description: General Characters.—A very beautiful complete specimen has recently (1912) come into the possession of Mr. Treacher. It has many secondary radioles adhering to its surface, and remains of the apical system are preserved in situ. Since the surface of the plates is rather encrusted, it seems better to describe the structural details from other examples. There are several connected fragments of this species in Mr. Treacher's collection, and all offer identical characters. They all represent rather small specimens of var. *typica*, but otherwise agree perfectly with the abundant isolated plates of both larger and smaller size. The complete specimen is the holotype. The original of Pl. XXVI, Fig. 11*e*, is the type of the radiole. The diagnosis and description of the species are generalized from over 200 plates and a far greater number of radioles. In case it should be shown that the fragments do not all belong to the same species, the name *coxwellensis* should be applied to the test.

The complete corona is somewhat depressed in shape. The diameter of the holotype is 25·5 mm., and its height 16 mm. The average size would seem to be about one and a half times as great as this, judging from the dimensions of the isolated plates.

The Apical System—One or two fragments of both ocular and genital plates occur in the holotype, but their characters, beyond that of a fine superficial granulation, are not well shown. The diameter of the apical disc is smaller than that of the peristome (12 mm. as against 13·2 mm.).

The Corona: Interambulacral Plates.—Average adult specimens of var. *typica* from the adapical region measure about 8·3 mm. longitudinally and 7·1 in their greatest breadth. The outline of the plates is thus proportionately taller than those of *C. faringdonensis*. The scrobicule is wide, circular, shallow, and near the adoral margin of the plate. The basal terrace is obscurely visible. The boss is central, often concave in section, sometimes dome-like, rising to a platform with a diameter less than a third the width of the scrobicule. The platform is practically flat, with no parapet, and is entirely uncrenelated. The mamelon is very large, of equal diameter with the platform, which is only visible under the undercut neck of the mamelon. The central perforation is relatively small. The scrobicular

circle is complete, surmounted by thirteen or fourteen secondary tubercles. These are separated from one another by spaces often twice as wide as their diameters. They are feebly developed, often hardly distinguishable from the miliaries, especially as they are set well back from the rim of the scrobicule. There is often a low ridge stretching radially from the rim to the tubercle. Outside the scrobicular circle, but often encroaching into it, is a complete cycle of tertiaries, often guttate in shape, with the prolongation separating the secondaries. There is very little difference in size between the secondaries and tertiaries. The miliaries are very small, and only one or two occur on plates of var. *typica*. They are fairly numerous, but still minute, in var. *major*.

Plates from the ambital region are slightly broader than high. The scrobicule is slightly to the adoral side of the centre. Apart from the miliaries, the plates agree in character with those from the upper cycles. The miliary zone is not appreciably increased in importance in var. *typica*, but in plates of var. *major* it is quite broad, and the granules are arranged in roughly horizontal lines, starting with the tertiaries, the lines being separated by distinct sulci. This is a very obvious feature, and *C. coxwellensis* is one of the earliest species to show the character. Measurements of an average plate from this region are: var. *typica*, height 7, breadth 7·2 mm.; var. *major*, height 9·2, breadth 11·3 mm.

As in *C. faringdonensis*, the scrobicule often assumes a slightly elliptical outline near the peristome. The miliaries dwindle in size and numbers until they are practically absent on the adoral plates. The auricles are too poorly preserved to merit description.

Ambulacral Plates.—There are about nineteen ambulacrals to one interambulacral at the ambitus. The poriferous zone occupies more than half the width of each plate. The pores are separated by a prominent granule. On the non-poriferous part of each plate is one very prominent granule (not quite reaching the level of the interambulacrals) which is usually accompanied by a much smaller granule on the perradial margin of the plate. The ambulacra have, therefore, four rows of granules, of which the outer rows are the largest. This applies to the smallest as well as the largest specimens examined.

The Primary Radioles.—These are very like the radioles of *C. pretiosa*, Desor. They are fairly long, but the length is somewhat counterbalanced by the breadth. Average radioles measure 38 mm. in length, and 5 to 5·5 mm. in greatest breadth. The stem is tumid, especially on one side, and is ornamented by rows of prominent, rounded granules, which are best developed on the tumid side. There are rarely any rows of granules which do not pass along the entire length of the stem. In some forms the granules are fused into denticulate carinæ. At the distal end there is a well-marked corolla. The collerette is very short, and not defined at its junction with the stem. The base is often wider than the broadest part of the stem, and the acetabulum is wide. The rim of the acetabulum is always smooth.

The Secondary Radioles.—These are very like those described for *C. faringdonensis*, but are always smaller. Those on the holotype

show that the striations on the outer surface become specially prominent towards the distal end.

Comparison with other species.—The outstanding features of the test of *C. coxwellensis* are the smoothness of the platforms and great size of the mamelons of the primary tubercles; the minute size of the scrobicular tubercles; and the paucity of the granulation (except in var. *major*, where the miliaries are horizontally arranged). The main characteristics of the radioles are the coarseness of their granulation, the inflation of one side of the stem, and the shortness and undefined limits of the collerette.

A comparison of the above summary of the characters of *C. coxwellensis* with that given for *C. faringdonensis* will be sufficient to show the extreme contrast existing between the two Faringdon species. Even a fragment of a plate or a section of a radiole are sufficient to distinguish to which form they belong.

The slight development of miliaries on the interambulacra of *C. coxwellensis typica*, and their linear arrangement in var. *major*, are characters which separate the species from practically all Neocomian and Cenomanian types. When the large development of the mamelon and the feebleness of the scrobicular tubercles are taken into account, a still more thorough distinction is seen. Perhaps it is with *C. pretiosa*, Desor, that the new species has most affinity. A comparison with that species is natural, owing to the extreme similarity of the radioles in both forms. However, in *C. pretiosa* a very anomalous feature in the ambulacra—that of a small outer, and large inner, row of granules in the interporiferous area—is a sufficient contrast from the definitely inverse proportions of the similarly placed granules in *C. coxwellensis*.

The radioles are very like those of *C. pretiosa*, differing from them only in the more marked corolla developed at the distal end. In view of the great abundance of radioles of *C. coxwellensis*, and the complete absence of any test fragments referable to *C. pretiosa*, it seems clear that this similarity of the radioles is no criterion of specific identity. In fact, since the radioles found on one specimen of a *Cidaris* may vary from one another very profoundly, it is natural that the converse condition of similar radioles in different species should occur.

Horizon and Locality.—Aptian (Lower Greensand) of Faringdon, Berks.

6. Undetermined Fragments.

Considerable numbers of jaw-fragments, chiefly hemipyramids and teeth, occur in association with the other *Cidaris* remains in the 'Sponge-gravels'. They are usually waterworn, but the measurements of the pyramids, and their large size, indicate that they belong to *Cidaris*. The smaller fragments probably belong to *Pseudodiadema* and *Peltastes*.

In conclusion, I wish to express my gratitude to Mr. Ll. Treacher for placing his unrivalled collection of Faringdon Echinoids at my disposal for the purpose of the foregoing description; and to

Mr. A. H. Malpas, of University College, Reading, for photographing the specimens.

EXPLANATION OF PLATES XXV AND XXVI.

Plate XXV: Cidaris faringdonensis, Wright.

Fig. 1. Paucigranulate plate from adapical cycle (var. *typica*).
,, 2. Average plate (same cycle) of var. *typica*.
,, 3. Multigranulate plate (same cycle), var. *maxima* (type).
,, 4. Intermediate form (var. *typica*) between Figs. 1 and 2.
,, 5. Two associated plates from near peristome (var. *maxima*), showing elliptical scrobicules.
,, 6. Mid-zone plate of var. *typica*.
,, 7. Plate from upper part of test (var. *typica*) with half an ambulacrum attached.
,, 8. Exceptionally high plate (adapical cycle) of var. *typica*.
,, 9. Adapical plate of small specimen.
,, 10. Genital plate (probably referable to *C. faringdonensis*).
,, 11. Ocular plate (probably referable to *C. faringdonensis*).
,, 12. Smallest plate found.
,, 13. Abnormal plate with two cycles of scrobicular tubercles.
,, 14. Radioles: (*a*) waterworn at distal end; (*b*) average specimen with rudimentary corolla; (*c*) showing proximal end unworn; (*d*) largest radiole found; (*e*) somewhat thick radiole; (*f*) regularly cylindrical form; (*g*) entirely smooth radiole, a variant, not due to erosion.

All the figures are reproduced at about 1¼ times natural size.

Plate XXVI: Cidaris coxwellensis, n.sp.

Fig. 1. The type, adapical view (var. *typica*).
,, 2. The same, adoral view.
,, 3. The same, lateral view.
,, 4. Segment of small specimen (var. *typica*).
,, 5. Connected fragment, showing ambulacrum (var. *typica*).
,, 6. Type of var. *major*, showing sulci between the miliaries.
,, 7. Plate with characters intermediate between var. *typica* and var. *major*.
,, 8. Tall adapical plate (var. *typica*).
,, 9. Average adapical plate, showing smooth parapet and small scrobicular tubercles (var. *typica*).
,, 10. Somewhat eroded plate of var. *major*, showing broad miliary zone.
,, 11. Selected radioles: (*a*) from adoral surface, rough side of radiole; (*b*) from higher region, smooth side; (*c*) from similar region, rough side, showing unequal inflation and rudimentary corolla; (*d*) longest complete radiole found, very little inflated, rough side; (*e*) radiole constricted towards distal end; (*f*) similar to (*b*), but showing rough side; (*g*) similar radiole, with proximal end well preserved; (*h*) similar to (*a*), but showing smooth side.

Fig. 3 is of the natural size, all the others are 1¼ times natural size.

II.—Post-Jurassic Earth-movements in South Africa.

By E. H. L. Schwarz, Professor of Geology, Rhodes University College, South Africa.

MR. BULLEN NEWTON has recently determined the fossils found by my students and myself in the Alexandria Beds near Port Elizabeth to be of Mio-Pliocene age; the full memoir will shortly be published in the Records of the Albany Museum,

Grahamstown. Hitherto the Alexandria Beds have been regarded as Danian on the strength of the evidence afforded by the Polyzoa and casts of Lamellibranchs, but the well-preserved shells on which Mr. Newton founds his determination of the age of the beds leave no doubt but that this earlier one is wrong. If the beds had been Danian there should be some connexion between these and the Pondoland Cretaceous in regard to the conditions of their deposition, which there is not. In trying to clear the way for a better conception I endeavoured to show that as the affinities of the Pondoland fossils lay with Cenomanian forms from Tunis, the age of the Pondoland Beds was towards the lower half of the Upper Cretaceous; then the supposed Cretaceous beds of Alexandria with Tertiary sharks' teeth would represent transition beds between the Cretaceous and Eocene. Dr. Kitchin, however, objected to this, as the Pondoland fauna taken as a whole was Turonian, if not Senonian, and the gap between the Pondoland and the Alexandria Beds became so small that there was not time for the undoubted changes in the land to have taken place which would have allowed the deposition of these several formations in the positions we now find them. The Pondoland, like the Uitenhage, Cretaceous beds belong to a period of sinking in the continent of Africa, at least as far as the southern and eastern portions are concerned, whereas the Alexandria Beds belong to a period of uplift. Mr. Newton's new determination, therefore, solves the problem; there are many other important considerations bound up in this matter. There is the question of the connexion of Africa and South America and perhaps Australia, in Tertiary times, to account for the distribution of the Proteaceæ among plants and many peculiar freshwater fish, for example, the Dipnoi, Chromididæ, and Characinidæ, among animals. There is also the question of the fragmentation of the Indo-African Continent, which is the explanation of the straight coastlines on the western side of the Peninsula of India, on the eastern side of Madagascar, and on the south-eastern corner of South Africa, as on this theory they represent fault-scarps. There is, again, the puzzling problems of the submarine features in the Indian Ocean, such as the level-topped, straight-edged plateau on which the Laccadive and Maldive Islands rest, that has been cited as evidence for the existence of submarine erosion, but which reminds one of a fault-block in Utah. All these points receive new light from the determination of the Alexandria Beds to be of Mio-Pliocene age, and I have thought it of interest, therefore, at this stage to piece together as far as is possible from our present state of knowledge the facts such as we know them in South Africa, and to draw from them a connected account of what movements went on in this part of the earth's crust.

We begin the story with the deposition of the Cape and Karroo formations, that is, of strata ranging in time from the top of the Silurian to the Trias. The two lower series of the Cape formation are marine, but in the uppermost series, the Witteberg, the Karroo Lake had already been enclosed by land and had become fresh, as witness the large amount of coaly material found in the beds and the delicate stems of the Bothrodendra with leaves attached, which could

not have stood the action of the waves in the open ocean. The southern margin along which the shallow-water formation, the Table Mountain Sandstone, was deposited was not very far from the present shore-line ; it was formed by the strand line of a prolongation of the Madagascar ridge. In early Cape times between this ridge and the rest of Africa there was a narrow strait, which became broader and deeper in Bokkeveld (Devonian) times, and was finally enclosed in Witteberg (Carboniferous) times. The succeeding Karroo rocks were laid down in this lake, having for a northern margin a line running through Prieska and the Southern Transvaal and a southern shore along the old Madagascar ridge. The Karroo sediments were laid down throughout in shallow water, ripple-marks being common throughout, but as they are some 15,000 feet thick, the floor on which they rested must have been continuously sinking.

The original floor of the Karroo Lake was thus bowed down by the weight of the ever-accumulating sediments, implying a very great height of and enormous denudation on the land now situated in Bechuanaland and the northern part of the Transvaal, and also of the old Madagascar ridge. The underlying rocks also participated in the downward movement and were in tension owing to the stretching due to the sinking. Into the cracks formed from this cause molten rock began to creep and gradually forced its way upwards, riddling the Karroo sediments with a plexus of dykes and sills of dolerite of so close a texture that one may regard the whole series of intrusions as constituting a single gigantic laccolite of the cedar-tree type.

The heat of the lower layers of the earth's crust had now become transferred to the upper layers by these intrusions of dolerite. The Karroo sediments, becoming heated, expanded, and in doing so the curvature of the basin of deposition would tend to straighten out. Whereas before the expansion there was a deep basin with a straight upper surface representing the last-deposited sediments, after the expansion the basin became less deep and the upper surface was a doubly inclined plane meeting in a crest in the middle where the thickest sediments had been deposited. This crest is the primary watershed of the country which originally stretched in an unbroken line from Cape Town to Delagoa Bay, but which is now broken once, and once only, by the Orange River at Aliwal North, the waters of this river having been forced over the watershed by the dam of lavas which were poured out in the Drakensberg. The Drakensberg volcanoes were consequently situated above sea-level and not submarine, as is often held to have been the case.

Besides this vertical uplift there was a lateral thrust also due to expansion. This, for some reason or other, found relief only on the south. On the north, perhaps because there was here the whole continent of Africa behind, no movement took place, but on the south there was only the Madagascar ridge, which we may suppose to have yielded somewhat to the pressure, and the movement once started caused the whole of the lateral thrust to become expended on this side. The shift of the Madagascar ridge can only have been small, not enough to accommodate the large amount of expansion caused by the intrusion of the Karroo dolerite. The surplus expansion was

relieved by the beds between the dolerite and the old Madagascar ridge folding into a number of sharp synclines and anticlines. There

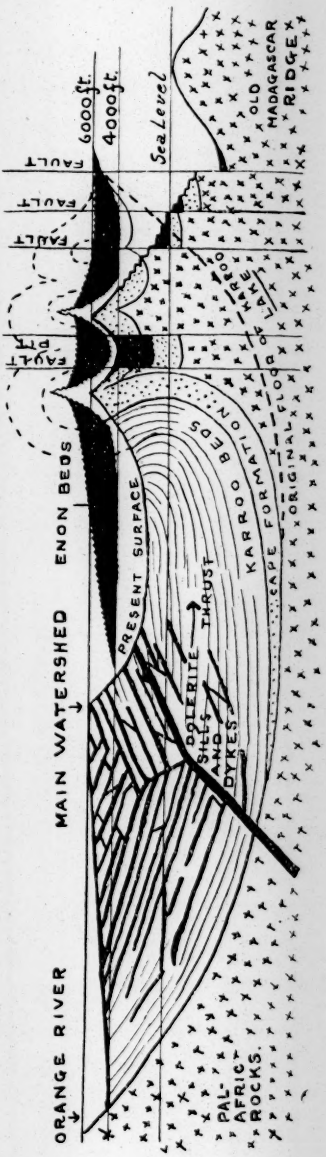


FIG. 1. Diagrammatic section through Cape Colony.

The Cape formation (Table Mountain Sandstone, Bokkeveld, and Witteberg Beds) is shown resting on Pal-afric beds (with crosses). They thin out towards the middle of the Karroo basin. The original basin of deposition is shown by the dotted line, and the old Madagascar ridge, now faulted below sea-level, formed the southern margin. The Karroo Beds are shown with the intrusive sills and dykes of dolerite. The Karroo Beds are scarped in the south, but fall gently in the north to the Orange River; the latter slope is very nearly the same as that which caused the main watershed to rise; the watershed is shown at the edge of the escarpment. The original folds of the Cape Mountains are indicated by dotted lines, and their contours in Lower Cretaceous times by wavy lines. The material (shown in black) resting on their flanks is the Uitenhage Beds (Lower Cretaceous), and very probably other and later beds. The manner in which these Cretaceous beds are let down into fault-pits into older and harder beds is shown between the two ranges of coast mountains as at Oudtshoorn, and by step faults as in the great Uitenhage basin. On the seaward side of the range the Klimakotopedim, on which the Alexandria Beds rest, is shown cut, sometimes in older, sometimes in Cretaceous rocks, down to the 90 fathom line (the Agulhas Bank). The descent to 400 fathoms is also shown, as well as the rise of the old Madagascar ridge on the far side.

is some difficulty in explaining how the earth's crust, structurally weak, can transmit a thrust of such magnitude; indeed, the area

between the dolerite and the folded mountains is traversed by a large number of quartz-veins filling in fissures, showing that the country has been stretched. The explanation of this lies in the fact that the thrust was conveyed by an infinite number of pulsations, small earthquake waves, which, like the waves of the sea, battered upon the shore represented by the old Madagascar ridge and caused the pressure to accumulate by insensible gradation. At any rate the dolerite dykes and the folded mountains stand in the relation of cause and effect. The commencement of the movement was contemporary with the outbursts of volcanic energy in the Drakensberg and also in the north in the volcanoes of the Kimberley series of pipes. In the east the Karroo Lake had a deep hollow in which sedimentation went on after it had stopped in the west, and the last undoubted subaqueous sediments are Rhætic. The Cave Sandstone and Red Beds which immediately underlie the lavas are more of the nature of mud and ash poured out of the volcanoes; the vertebrates, however, found embedded in these latter are Jurassic—Dinosaurs and primitive mammals. The main folding was finished before the Cretaceous period, for the Neocomian beds are unaffected.

The folded mountains reached to a very great height as compared with the present sea-level, but then the land lay from 4,000 to 6,000 feet lower than it does now. The rocks involved in the folding and structurally weak from the bending yielded enormous debris heaps, *Schutt-halden*, which formed at their bases. There seems to have gone on a sort of contemporaneous erosion and deposit of a peculiar kind and on a gigantic scale, for the rivers and torrents with their burden of gravel cut a level peneplane at 4,000 feet above the present sea-level and then left behind on the plain a pile of gravel which reaches 2,000 feet in thickness in places. This is the Enon conglomerate, the lowest member of the Uitenhage (Neocomian) Series. The mountains, then much lowered in altitude by the action of torrents and swaddled at their bases with the Enon conglomerate, no longer formed the collecting-points for the moisture-laden clouds, and the country instead of being lashed with storms became tolerably dry, or even desert, with, however, occasional lakes. In Central Asia we have very similar conditions at the present day, and, to complete the similarity, the Himalayas, Karakoram, and Kuen-Lun Mountains shortly after their elevation yielded vast plains of boulders like the Enon at no very remote date, just as our coastal mountains in South Africa did in Lower Cretaceous times. The deposits of this dry stage are represented by the Wood Bed, the middle series of the Uitenhage formation; the strata consist of marls, gypsiferous clays, blown sand, and lake deposits. In the last a rich flora of Cycads, ferns, and conifers has been found which are of Wealden age. On the margins of the lakes Dinosaurs still continued to roam, but only a few have been found; one complete one unearthed at the Despatch Brickfields, near Uitenhage, was converted into bricks before it could be saved; only a few pieces have yielded Dr. Broom sufficient material on which to found his genus *Algoasaurus*.

The land, however, was sinking, and at the close of the Wood Bed period the sea invaded the land and flowed probably up to the central

escarpment of the Karroo. The beds laid down are richly fossiliferous, and from them Plesiosaurs, Ammonites, Trigonias, and other Lower Cretaceous marine forms have been obtained. These are the Sunday River Marine Beds. Now comes a gap in our knowledge. From the Neocomian to the Mio-Pliocene nothing is known in the midlands of South Africa. In the east, in Pondoland, there is a patch of Upper Cretaceous deposits and in Zululand beds of a slightly lower horizon. In both these cases the strata lie against a fault-scarp of much older beds and have therefore been dropped down just as the Uitenhage Beds have been; in fact, there can be little doubt that the faults in both cases belong to the same system and are very little, if at all, separated in age. This consideration leads one to the conclusion that Lower Cretaceous beds occur beneath the Upper in Pondoland and Zululand, and that consequently the Lower Cretaceous strata in the midlands and west of Cape Colony were followed originally by Upper Cretaceous deposits, which have now, however, been entirely removed by denudation. In Madagascar on the west there is a complete conformable series through the Juras and Cretaceous to the Tertiary, and the tilting of these beds westwards connects the beds so tilted with the faulted strata in Cape Colony.

It should be noted that at this time Madagascar was in all probability joined to the mainland by a land bridge through the Comoro Islands, and in the bay between the island and the mainland the complete conformable series of rocks above-mentioned were laid down. Traces of the upper part of the series is found in Zululand, but the faulting to be described below intervened and cut up the mainland side of the bay. In Madagascar the eastern side is a sharp fault-scarp as shown by the almost straight coastline, but on the western side the beds have been merely tilted. We know from the fault-troughs in Baviaan's Kloof that as a rule the slices of the earth's crust let down in this region are faulted on the side towards the land and bent downwards on the side towards the sea, so on this evidence the deep channel between Madagascar and the mainland is a normal interrupted trough fault or pit of the Baviaan's Kloof type.

At any rate, we may suppose that after the Sunday River Marine Beds of Uitenhage were laid down, the whole of the southern portion of South Africa was beneath the sea, and beds of sand, mud, and limestone, now entirely removed, covered all the country even as far west as Cape Town, and that this deposition went on into the Eocene period.

At the close of the Eocene period, or at least before the Miocene, the old Madagascar ridge became faulted down. The crack or fault sliced off the eastern corner of South Africa and spread northwards along the Lebombo Mountains, separating the Eastern Transvaal from Portuguese East Africa, then upwards along the Shiré River to the great western and eastern rift valleys to the Red Sea. On the landward side of the fault the country rose in compensation. Denudation started to work at a rapid rate, removing all the loosely compacted rocks but recently laid down, and would have swept them entirely away but for the fact that there was developed a system

of fault-troughs which let down slices of the earth's crust into pits where the loose Cretaceous rocks were protected by being entirely surrounded by hard ancient rocks. Although these fault-pits are shown in section as ordinary faults, they partake more of the nature of holes caused by tearing along a zone of shearing. One can illustrate their nature by taking a slab of stiff clay and pushing the two ends of it in different directions over a polished table; in the zone of shear a number of eye-shaped holes will appear, whose shape the fault pits of the south-western districts of Cape Colony actually have, and it is in these eye-shaped holes that there now exists what little remains over of the Cretaceous beds.

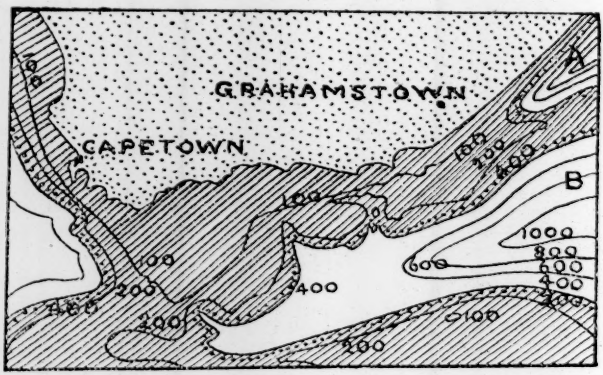


FIG. 2.

Sketch-map of the floor of the ocean south of South Africa, based on the Admiralty charts. The sculpturing of the sea-floor down to 400 fathoms is shown and also the tailing out of the deep trough (rift-valley ?), A, that separates Africa from the Madagascar ridge, and the commencement of another, B, directed to the east. Dotted portion indicates present land surface; ruled portion the area of the sea-floor that shows evidence of terrestrial erosion.

If one glances at the sketch-map, Fig. 2, it will be seen why the faults which let down the Uitenhage Beds are connected with the Great Rift Valley System in Central Africa. The latter comes south through Lake Nyasa and along the Shiré River; then in a curved line there is a fault which forms the western boundary of a rift-valley, the eastern scarp of which is hidden under the sea, or, as I have previously mentioned, is probably represented by the monocline on the west of Madagascar. This great island is again simply a horst like the Colorado plateaux with fault on east and monocline on west. At all events, the fault-line from the Shiré River turns to the south-east and on the east there are low-lying tracts of land underlain by Upper Cretaceous rocks, forming Portuguese East Africa and Zululand; a last little patch is left near the Umzamba River in Eastern Pondoland. From here the fault-line forms the actual boundary of South Africa as far as the mouth of the Bushman's River, south of Grahamstown. The deep trough, A, in the sea-floor tails out here also, and the system of faults which lets down the Uitenhage

Beds begins. This system stretches certainly from the mouth of the Bushman's River to Worcester, a distance of 400 miles, in an east and west direction, although the direction of the faults in the various fault-pits varies owing to the original grain of the country which was determined when the mountains were folded; thus the Bushman's River fault along which the lower course of the river is cut is W.N.W.–E.S.E. The general arrangements of the series of fault-pits and their dominant marginal faults is east and west. The interruptions of the fault-troughs, which convert what are in all characteristics rift-valleys into a series of isolated pits, are always in a N.E.–S.W. direction, that is, in the direction of the faulted coastline of the eastern corner of South Africa and its accompanying trough in the sea close inshore. The E.–W. direction is that of the second and larger trough (Fig. 2, B) which also tails out here, but proceeds a little further west than the other, so it is to this fault-trough that the truncated end of South Africa owes its origin. The fault-pits in which the Uitenhage strata lie are due, therefore, to the crossing of two systems of faults, or rather are marginal shearing-fractures of two great fault-troughs which are directed respectively E.–W. and N.E.–S.W. It is necessary, however, to establish that the E.–W. trough in the sea is a rift-valley. If we admit that the trough A is a fault-trough, which does not seem to admit of doubt, as we see one side of it actually above sea-level in Pondoland with Upper Cretaceous rocks against it, then the N.E.–S.W. fractures of the fault-pits with the Lower Cretaceous rocks against them are connected with it in the same way as the smaller trough-faults of Egypt are connected with the larger one of the Red Sea. The E.–W. fractures, which form the other two sides of the fault-pits, parallel to the E.–W. trough B, would also be connected with a fault-trough, and thus from their association with the other fractures make it highly probable that this second trough is a rift-valley beneath the sea.

I have said that Madagascar is a horst of the Colorado plateau type with strike a little east of north. If there are E.–W. rift-valleys, there ought to be horsts of the same nature as Madagascar with this strike. In Schott's map of the Indian Ocean accompanying Chun's *Aus den Tiefen des Welt-Meeres*, Jena, 1900, these E.–W. horsts are very clearly demarcated. From the south northwards, there is, first, two blocks extended east and west with straight sides, on which the Prince Edward and Crozet Islands lie, then the Rodriquez bank, and then the Seychelles bank. Corresponding to these there are straight-edged banks running N.–S.: first, that on which the Laccadive, Maldive, and Chagos Archipelago stand, then the banks of Saya de Malha and Albatros Island, north of Mauritius, and far to the south the bank on which Kerguelen and Heard Island stand; the last, however, trends west of north at about the same angle as Madagascar does east of north. All these submerged plateaux from their nature appear to claim to be parts of the fragmented Indo-African continent, and faults that left them standing while the rest of this part of the earth's crust sank were probably contemporaneous with those that affected the southern portions of Cape Colony. The only doubt that can be thrown upon this contemporaneity is due to the fact that the

Red Sea, which is a rift-valley belonging to the great Indo-African fragmentation, has sunk in Pleistocene times, at least the northern portion; in this case, however, the rift had already formed long previously, and the fact that the sea invaded the trough only in Pleistocene times merely indicates its depression below an arbitrary datum depending on the amount of sea-water upon the globe. The bottoms of other rift-valleys, such as those in Central Africa, are much above sea-level, as others, for instance that off the coast of South Africa, are much below. That movements should happen in Pleistocene times in these troughs is a natural consequence of the strained equilibrium resulting in large movements in the earth's crust, and may be regarded as 'posthumous' movements along lines of weakness formed long anteriorly, just as the fold of the Weald in the South of England is a posthumous fold which followed lines of folding that was brought to a close in Carboniferous times. What I wish to establish is that the general fragmentation of the Indo-African continent took place in pre-Miocene times and was finished in pre-Pleistocene.

The next event in South Africa of which we have any evidence is a peneplane now elevated 4,000 feet above sea-level. Only river gravels are found upon it, and these quite barren of organic remains. It is extensively developed on the inside of the coast ranges, and extends along the escarpment of the Karroo Beds in Fort Beaufort and King Williamstown; from Grahamstown it may be seen as a sharp line below the 6,000 feet level of the Great Winterburg and Amatolas. The 4,000 feet peneplane is thus a level of general denudation, and implies that the land stood at this level above the sea; it is quite different from the 4,000 feet level on which the Lower Cretaceous beds, the Enon conglomerate, was deposited, for this new 4,000 feet level cuts off the tops of the tilted Enon conglomerate and covers them with *remanié* gravels lying perfectly horizontally. We do not know the date of this plain because there are no organic remains in the gravels and sands with which it is covered, but the land was now again rising, and after cutting a very widespread peneplane at 2,500 feet above present sea-level, it rose to 15,000 feet above sea-level, when for the first time the Alexandria Beds, Mio-Pliocene, were deposited. The second 4,000 feet peneplane is thus about Oligocene or early Miocene.

From the 1,500 feet plain or coast shelf—for now the plains are no longer extensive peneplanes but narrow shelves fringing the coast—there are a succession of ledges cut at intervals of 50–100 feet downwards, extending like the steps of a flight of stairs to below sea-level. As our coast surveys show the sea-floor carved into narrow river gorges down to 400 fathoms, one may perhaps be justified in concluding that this level was at that time exposed as dry land. The submarine contours show that at 400 fathoms the old Madagascar ridge was connected to the Cape Peninsula, and that river courses ran both to the east and west from the narrow connecting ridge. From a general view of these contours one may infer that the river system at the time of maximum elevation was somewhat different from what it is now: only two rivers, the Gouritz and

Gamtoos, reached the sea; the others, which now have separate mouths, then formed tributaries of these two large rivers.

The movement seems a gigantic one, but the data we have to rely upon are sound; only the time taken for these changes of sea-level is open to some doubt. There has been rising of the land from the 4,000 feet peneplane to sea-level, and from here to the 400 fathom line, 6,400 feet, then a sinking of the land 2,400 feet to present sea-level. All this was accomplished in pre-Pleistocene times, because the rock-channels of the rivers which cut through this stepped plain, such as the Keurboom, Pisang, Zwartkops, Kowie, and Buffalo, are filled in now at sea-level with Pleistocene beds. Hence the whole oscillation took place within the Miocene and Pliocene times. 6,400 feet vertical rise and 2,400 feet vertical sinking, or 8,800 feet of total movement. If the evidence below sea level is objected to, the undoubted movement is still 4,000 feet.

Certainly the portion from sea-level to the 90 fathom contour is cut into ledges such as one sees in Uitenhage or Pondoland; below this the descent to 500 fathoms is steep, and there is so much glauconite sand that the surface contours are obscured. Further out, the sea-floor rises again to 200 fathoms, and in one place opposite the Gamtoos River to 100 fathoms; this is the remnant of the old Madagascar ridge.

This stepped or terraced plain, covered with Alexandria Beds, which are the same when examined from either the top or intermediate levels or even from the lowermost at sea-level, belongs therefore to one and the same period. I have called such a stepped plain a klimakotopedim. Lyell describes a similar stepped plain in miniature in his *Travels in North America*, London, 1845, vol. ii, p. 39: "In proportion as the Ohio falls gradually in level after its inundations, it leaves a great succession of steps cut in its mud banks, each from 4 to 10 inches above the other. It appears to me an exact miniature representation of the form in which the waves have denuded the land on the sides of some valleys in the limestone districts of Sicily and other countries bordering the Mediterranean." The last fact is important, and one which I have not seen mentioned elsewhere, because this African stepped plain is covered with a deposit in which are found species identical with the Mediterranean Mio-Pliocene forms.

Since the land stood exposed down to the 400 fathom line it has sunk and the ends of the rivers of South Africa show deeply excavated rock channels now filled in with Pleistocene sand and clay. The present movement apparently is an elevatory one; recent sea-beaches are seen along the shore elevated 10 feet above sea-level, but no direct proof is forthcoming.

The movements I have been discussing are direct elevatory ones, or the reverse, of the solid crust and were caused by folding and faulting. The alteration of sea-level due to the attraction of the outstanding portion of the land on the water must also have been intense; when the folded coast mountains were first formed a great pull would have been exerted on the sea by these towering ranges, and, as they became denuded and surrounded with debris and eventually swamped by the sea, their attraction became reduced

to nothing. Now in the course of ages they have once again emerged by the removal of the loose material around them, and they rise to the 6,000 feet level and must by their attraction cause the sea to heap up in their neighbourhood. As a matter of fact, it is probable that the sea-level is higher around Cape Town with its backing of great mountain ranges than it is at East London, where there is merely a stepped plain presented to the sea.

III.—Palæontology and Bernard's Biological Theories.

By W. D. Lang, M.A., F.Z.S.

I.

PALÆONTOLOGY is the biology of fossils. The palæontologist, therefore, is bound to consider modern biological views in order that he may test them in the light of his science. It is intended here to apply to one class of fossils the fundamental principles upheld in a remarkable work by the late H. M. Bernard, entitled *Some Neglected Factors in Evolution*,[1] really two books under one cover, the first dealing with the ultimate structure of protoplasm and the second with a method of organic evolution. The principles underlying the first suggest the methods of the second; so that in approaching the second a thorough knowledge of the first is needful. Before applying it let us examine the theory itself.

Hitherto, says Bernard, the morphological aspect of biology has been dominated by the idea that all organisms are either cells or cell-aggregates. The cell has been regarded as the unit of all higher structures, and, although in its turn the cell is variously composed of simpler factors (cytoplasm, nucleus, chromosomes, etc.), these have never been, in fact obviously cannot be, regarded as homogeneous units, building up the cell in the same manner as the cell builds up a tissue and, finally, a whole organism. Now this cell-doctrine is far too rigid to explain many well-known morphological phenomena, and to do so in terms of the doctrine involves extending the definition of a cell beyond convenience; and the idea of a cell has consequently obscured the significance of what has been observed. Some authorities, it is true, have refused to wear the blinkers of the cell-doctrine, and, though they have seen further in consequence of their action, they have not co-ordinated their observations by any theory transcending that based on the cell.

Bernard's theory demands that the cell shall be itself an aggregate composed of homogeneous units. In order to discover these units it is necessary to determine what morphological factors invariably are present in protoplasm. These are found to be three: a deeply staining factor bearing chromatin and occurring in minute bodies—chromidia, fibrous filaments composed of linin, and a pervading liquid matrix. The simplest imaginable connected and symmetrical grouping of these factors has the form of a three-dimensioned linin network with the chromidia at the nodes and the whole bathed in

[1] *Some Neglected Factors in Evolution, an Essay in Constructive Biology*, by Henry M. Bernard, M.A. Cantab., F.Z.S., ed. by Matilda Bernard. 8vo; pp. xxii + 490, text-illustrations. G. P. Putnam's Sons, New York and London, 1911.

the 'cytoplasmic' matrix. The unit of this arrangement, then, is a single chromidium with radiating linin strands; and a homogeneous aggregate of such units is the linin-chromatin, or, as Bernard calls it, the 'protomitomic', network.

Such a network is the condition of cells that have no apparent nucleus, or of those which, in terms of the cell-theory, the nucleus is fragmented. And the reason why this structure has not hitherto been postulated as fundamental in all protoplasmic bodies, is that in general circumstances the linin is invisible by our present means of vision; but when chromidia stream along the filaments, owing to their staining properties, they cause the filaments to appear. Then they have been observed, for instance, in a nucleus dividing by mitosis; and variously accounted for. For the linin strands are the paths of the chromidia which in their turn are the storehouses of energy. Where work is done, and in proportion as more or less energy is required, thither and in greater or less quantity stream the chromidia along the linin strands. The strands are essentially contractile as well as capable of transmitting stimuli from the exterior to other portions of the network, and it is specialized bundles of linin strands that ultimately form nervous and muscular tissue. It is along them, too, that waste matters travel outwards and are deposited either around the strands (or bundles of them) or at their tips, forming an endo- or exoskeleton.

The cell is derived from the primitive linin-chromatin network by the massing together of the nodes and the consequent tangling of the linin threads. The massed nodes constitute the nucleus, and the linin filaments, though tangled, have as a whole a radial arrangement, and their ends, projecting from the 'cytoplasmic' matrix, either singly or in strands, appear as cilia.[1]

Homogeneous aggregates of cells form three-dimensioned networks very similar to the primitive protomitomic network, but on a larger scale and essentially of a more complex structure. Examples of such are *Volvox* (fig. 21, p. 107), the larval sponge (fig. 14, p. 91), and the tissue of the vertebrate retina (fig. 33, p. 218).

Such, in bald outline, is Bernard's protomitomic theory, if I have rightly understood it. The evidence adduced in its support is mainly that of structures such as the vertebrate retina and the nuclear spindle and centrosomes of karyokinesis, difficult of explanation by the cell-theory, but easily accounted for if Bernard's point of view is accepted. Moreover, his view reconciles different and apparently exclusive theories of protoplasmic structure, such as the 'foam-structure' theory of Bütschli, founded on the globular appearance of the albuminous matrix between the protomitomic meshes, and the 'biophor' theory of Altmann, the granules of which are the chromidial nodes.[2] The protomitomic theory does not annihilate the cell-theory,

[1] Bernard's explanation of the nuclear wall as a felted tangle of linin threads is not very convincing, for the tangling would, presumably, be greatest at the nucleus and *gradually* less towards the periphery of the cell.

[2] The reader must refer to the work itself to gain a proper idea of the number of otherwise inexplicable phenomena in morphology that can be readily construed in terms of the protomitomic theory.

rather it transcends it by regarding the cell as one particular kind of grouping of homogeneous units themselves built on a definite pattern. Thus, while the cell-doctrine lays stress upon the nucleus and the cytoplasm as essential factors of the cell, Bernard emphasizes the nucleus and the linin threads, the cytoplasm being composed of these and a pervading albuminous matrix. The significance of each point of view is seen when cell-aggregates are considered. To the cell-doctrine they are merely aggregates, though, since they act as a whole, there is some unknown co-ordinating influence. This, according to Bernard, is exerted by means of the physical continuity of the linin threads from cell to cell, continuous because they have never been separate. For a dividing nucleus implies a division of every chromidial unit of which it is composed and a longitudinal splitting of those linin threads in the plane of division and a lengthening of those at right angles to this plane.

The invariable presence of linin threads and their continuity from cell to cell is thus the essence of the theory from the point of view of the cell-doctrine. And here the critic may find an assailable point. Bernard's position is that, except when chromidia are travelling along them, the linin threads are invisible (with our present powers of vision). The scientific purist may deny the right of assuming the presence of a structure in any case when its existence cannot be proved by definite tests; the onus of proving the linin threads' existence in every case lies with Bernard. Bernard adduces certain cases where the threads are visible, shows that the protoplasm is then in a condition (e.g. when repeated nuclear division is taking place and chromidia streaming along the threads in consequence, or when waste products are being copiously conveyed along them) when on *a priori* grounds it is to be expected that the threads will temporarily be visible, and argues that it is fair to assume that they are always present, though often invisible. He thus leaves it for his critics to prove the absence of threads, disarming criticism by presenting a negative for proof. Future work alone will show whether the threads are invariably present. Hitherto they have not been sought, and have been noticed only when they could not well be disregarded. It is incumbent upon future workers to have this theory in mind and in its light to test the work already done. It is for this testing that Bernard pleads.

Bernard's first book, then, might be summarized as follows:—Protoplasm, in the simplest manifestation of its structure to which our present powers of vision can take us, consists of a network of linin threads with chromidia at the nodes, bathed in an albuminous matrix; a particular form of such a network, wherein the chromidia are massed in a central ball and the linin threads consequently tangled but still radiating from the central mass of chromidia through the albuminous matrix to the surface, constitutes the typical cell of the cell-theory.

II.

The idea of a cell as a particular grouping of homogeneous units, and at the same time one of many similar units that build up an organism, led Bernard to conceive the possibility of a unit of higher

degree than a cell, from which higher metazoa were built; and he thinks he has found this in the 'gastræa'—the simplest expression of the morphic principle of the Cœlenterate; and above the gastræa two more units of progressively higher order. In each case more complex organisms are formed by aggregations of similar units, and one specially efficient form of grouping constitutes a new unit from which the process may begin again.

Hitherto organic evolution has been looked upon as an advance from the simple to the complex, from the homogeneous to the heterogeneous, and the advance along any one line as straightforward, though the steps may be more or less gradual or sudden. But, in the light of different orders of units, organic evolution is seen to proceed in periods, and periodic or rhythmic evolution is the theme of the second part of Bernard's book.

How many pre-cellular periods have occurred we do not know, but we know one—that of the protomitomic network seen in certain organisms (e.g. microbes and other non-nucleated protoplasmic bodies), and we may reasonably expect that earlier periods behaved similarly to this and to all subsequent periods. Now one fundamental character common to the units of all periods is an alternation of growth and fission; the unit cannot surpass a certain maximum size, and when this is reached it divides by fission (secondarily modified into budding). The simplest conceivable unit is a molecule of protoplasm. If such existed as a period, we must allow that it differed from every inorganic molecule by the possession of this periodic rhythm of growth and fission as well as the two next-mentioned characters. The first of these is the capacity of forming colonies by means of incomplete fission. The colonies are formed in great variety of manner, and one particularly efficient arrangement forms a new unit. A third fundamental property of the units is that of morphic response to the environment. That is, by exploring new environments, their structure (often only after the lapse of generations) becomes variously and suitably modified. Now the process of organic evolution seems to have been as follows:—A structural unit (of whatever order) multiplying by fission spreads in all directions into new environments and becomes accordingly variously modified, i.e. it passes from the simple to the complex, from the homogeneous to the heterogeneous. Simultaneously, by incomplete fission it forms colonies—homogeneous aggregates, whose units, however, are variously arranged; and one especially efficient arrangement becomes a new unit. The process is then repeated as a second period, and so on.

We have spoken of a hypothetical molecular period. Other periods are passed through until a pre cellular period of which we have knowledge is attained. This has the form of a chromidium with radiating linin filaments. A colony of such units is the protomitomic network. One particularly effective arrangement of this is the cell, formed by a massing of all the chromidial nodes into a central nucleus. The cell is the new unit of a new (cellular) period. As a unit it has advanced from the homogeneous simple form to the heterogeneous complex structures such as *Paramœcium* and the

Radiolaria. As colonies formed of homogeneous units it has built up certain forms such as the Sponge, the Cœlenterate, and some Flat-worms.[1] Now the efficient arrangement of the pre-cellular unit that gave rise to the cell was obtained by the massing of chromidia (the essential chemical factor of the organism) to the centre, and by spreading around this central mass radiating fibrous elements. The same principle is seen in the gastræa, but here the massed nuclei surround a central digestive cavity, while in the outer zone the fibrous elements are specially developed and already are beginning to differentiate into muscles and nerves. The variety of cœlenterate forms shows the passage in this period from the homogeneous to the heterogeneous, while colonies of Corals, Hydrozoa, etc., are homogeneous aggregates. Bernard supposes that the next new unit was formed by a colony arranged so as to form a chain of gastrææ with the Cœlentera of all the individuals connected up and the muscular and nervous systems better developed. Such a colony would be primitive annelid, and those annelids that branch and form chains of individuals represent aggregates of the new unit.[2] If the passage from the gastræal to the annelid period is scantily and unconvincingly demonstrated, still more so is that from the annelid to the vertebrate period. Bernard dismisses this with very few words; and here is, perhaps, the weakest part of his book. A scheme of animal evolution to be convincing should above all help to elucidate the vexed question of the origin of the vertebrates, instead of slighting it. After the vertebrate unit is reached, the aggregates are social, and, since the tie connecting the individuals is no longer a physical one, the scheme passes out of the natural sciences into the metaphysical, and consequently no longer concerns us as palæontologists.

III.

It is not the object of this paper to give all the evidence for and against the views put forward, and the reader must refer to the work itself to form a true judgment. Had Bernard lived longer, no doubt he would have tested his theories fully; as it is, he appeals to his readers to do so, and, if this sketch has been the means of bringing his views to the notice of palæontologists, it will have accomplished an object. But the paper is primarily intended to show how Bernard's theories may be applied directly in palæontology and give a helpful view of phenomena.

Two outstanding points in Bernard's book are his insistence on the

[1] In embracing Mollusca among simple cell aggregates and apart from annelids, surely Bernard fails to account for such forms as show traces of segmentation and other suggestions of alliance with annelid worms, such as the trochosphere larva; see Pelseneer, "La Classification générale des Mollusques": Bulletin Scientifique de la France et de la Belgique, vol. xxiv (1892), pp. 368–71, 1893, and "Recherches morphologiques et phylogénétiques sur les Mollusques archaïques": Mémoires Couronnés l'Acad. roy. belgique, vol. lvii, pp. 83–8, 1899.

[2] The position assigned by Bernard to *Sagitta* is interesting. It is an aggregate of gastræal units arranged on a different plan from the typical annelid grouping and near that of the hypothetical vertebrate ancestor, but, being of insufficient efficiency, it has failed in its turn to become a new unit.

universal presence and importance of radiating linin threads that connect unit with unit and the periodicity of evolutionary processes. In consideration of the first point, Bernard claims as one of the most primitive and fundamental functions of the linin filaments the conveyance of waste matter towards the periphery of the organism. In some cases waste matter is deposited around the filaments as a sheath, and so spicular skeletons are formed. In other cases the waste matter is laid down at the ends of the filaments forming cuticular and other exoskeletons. Under the former category fall the Alcyonarian and under the latter the Madreporarian coral skeletons. Now two differing theories have been held regarding the formation of the latter skeletons, namely (1) that ectoderm cells secrete calcareous matter on their outer surface,[1] and (2) that ectoderm cells secrete such matter internally and gradually convert themselves into the granular elements of the skeleton.[2] The last great work on the microscopic structure of the Madreporarian skeleton was that of Ogilvie,[3] who described the granular unit that composed the coral skeleton as a cake-shaped mass built up of calcium-carbonate fibres and produced by a calcified ectoderm cell ('calicoblast').[4] Ogilvie claims to have found organic matter (the remnant of the chalicoblast) mixed up with the granule, so that the granule is not a mere secretion on the outside of the ectoderm cell (as Bourne has since reaffirmed).[5] Whichever view is right, neither explains the minutely fibrous structure of the granule. The simultaneous secretion of all the chalicoblasts forms a pavement of granules, and beneath this another layer, and so on, until the skeleton consists of many growth-lamellæ. Regarded in a direction at right angles to the plane of the secreting surface, the skeleton consists of piles of granules heaped up over the chalicoblasts, though, naturally, not so regularly as can be imagined.

Now, instead of a row of chalicoblasts laying down calcium carbonate within or without themselves, let us, with Bernard, regard the secreting surface as a cytoplasmic plane studded with the ends of the bundles of linin filaments, each conveying calcium carbonate from the interior and laying it down at their ends. The resulting skeleton would be a succession of sheets, each a superficial layer of minute specks of calcium carbonate far smaller than the granule secreted by a chalicoblast. Regarded in a direction at right angles to the secreting surface, the skeleton would be seen to consist of fibres, each composed

[1] Von Koch, "Ueber die Entwicklung des Kalkskeletes von *Asteroides calycularis*, und dessen morphologischer Bedeutung": Mittheilungen aus der zoologischen Station zu Neapel, vol. iii, pp. 284–92, 1882; and Bourne, "Studies on the Structure and Formation of the Calcareous Skeleton of the Anthozoa": Quart. Journ. Micro. Sci., N.S., vol. xli, pp. 499–547, 1899.

[2] Von Heider, "Die Gattung *Cladocera*, Ehrenberg": Sitzungsberichter der Kaiserlichen Akademie der Wissenschaften, Wien, vol. lxxxiv. pt. i, pp. 634–68, 1882; and Ogilvie, "Microscopic and Systematic Study of Madreporarian Types of Corals": Phil. Trans. Roy. Soc. Lond., ser. B, vol. clxxxvii, pp. 83–345, 1897.

[3] Op. cit., under (2).

[4] 'Chalicoblast,' von Heider, op. cit., under (2), p. 651, not 'calicoblast', after Bourne and Ogilvie (χάλιξ, 'a stone').

[5] Bourne, "Anthozoa," p. 80, in Lankester, *A Treatise on Zoology*, 1900, pt. ii.

of a pile of the minute specks of calcium carbonate and reposing on the end of a bundle of linin threads. We have thus reached a smaller skeletal unit than the granule, namely a micro-granule, secreted at the end of a linin-thread-bundle. A pile of these forms a skeletal fibre; a bundle of fibres forms a granule which exists as a separate entity in virtue of the chalicoblasts being differentiated as cells, i.e. though connected by linin filaments the cytoplasm is arranged in groups each dominated by its several nucleus. Except, however, at the surface where the skeleton has only just been secreted, the outlines of the granules vanish, and the skeleton has a fibrous structure alone.

Any section of a fossil coral, if well enough preserved, shows a fibrous structure (I am not aware that fossils are ever so well preserved that the lines of growth described by Ogilvie in recent corals appear), and the septa invariably, and other elements variously, have a median (generally) dark line. This dark line is the expression of the secreting surface folded upon itself; each side of the fold secretes the fibrous skeleton, and the line marks the junction of the two layers. The skeletal parts other than the septa may be interpreted as secreted by a double or single ectodermal surface according to whether they have or have not the median line. Ogilvie explains how complex folding of the secreting surface causes the skeletal fibres to appear rather to radiate from centres than to be pinnately arranged on each side of the median line.

We have now seen that Bernard's theory explains the fibrous coral skeleton whether the fibres appear in the section of a fossil or as composing a granule isolated (as achieved by Ogilvie) from the septal surface of a recent coral. It is also conceivable that, if secretion were quickly taking place, calcium carbonate might be deposited just beneath the surface of the cytoplasm round the end of a linin-thread-bundle as well as at its end, and so pieces of cytoplasm might thus get entangled in the general skeletal layer and give the appearance that suggested to Heider and Ogilvie that a whole chalicoblast was converted into a granule of calcium carbonate.

Periodicity in evolution is the second principle just mentioned as standing out from Bernard's work. It is here suggested that this principle has a far wider application than that given it by Bernard. Demonstrated by him as evident in the evolution of animal phyla, periodicity is here claimed as bound up also with ontogeny and possibly related to tachygenesis.[1]

Wilson has shown in the development of the coral *Manicina*[2] that the first six mesenteries appear singly, though the last four of these follow so closely upon one another as rather to resemble the entrance of a pair of pairs. In other Cœlenterates the mesenteries have been described as appearing in pairs or in cycles. The first mesenteric period of *Manicina*, then, may be called the 'single' period, since its structural unit is a single mesentery; its first phase (anabasis) is the production of the first two mesenteries, one after the other; its

[1] Hyatt, "Bioplastology and the related branches of Biologic Research": Proc. Boston Soc. Nat. Hist., vol. xxvi, p. 77, 1893.

[2] Wilson, "On the Development of *Manicina areolata*": Journ. Morph., vol. ii, pp. 191–248, 1889.

developmental aim is to produce mesenteries in pairs, shown in the second phase (acme), and so perfected in the third phase (katabasis) that this phase reproduces the idea of the first, since the two mesenteries appear practically as a single unit. Our new structural unit is now a pair of mesenteries, and the second six mesenteries appear in pairs and constitute a second period. We are, however, not directly concerned with the further development of mesenteries, for it is in fossils that we are looking for periodicity in development. But, since the septa follow and to some extent are determined by the mesenteries in number, position, and time of appearance, it is well to realize that mesenteries have a period in development whose structural unit is a single mesentery, prior to one with a pair of mesenteries for its structural unit. The most primitive septal development yet described is that of *Zaphrentis*.[1] Carruthers figured three stages in a 'paired' period in this form, namely, stages with two, four, and six septa respectively. The next period in *Zaphrentis* and in Rugose corals generally has still a pair of septa for its structural unit, but instead of being added to the previous septa as if these constituted but one system, the new septa appear in pairs independently at two levels, one in the 'dorsal' and the other in the 'ventral' parts of the corallum, as if the previous septa formed two systems. Since the resulting appearance is three fossulæ, this period may be called the 'fossular' period. After a time, new septa no longer are added in pairs about the two levels, but a 'cyclic' period is introduced, the structural unit being a complete cycle of septa interposed between those already existing. Three points are remarkable in the cyclic period; in, at any rate, most Rugose corals but one cycle is thus produced; often the cycle is not perfect in its time of appearance, but the septa in the neighbourhood of the counter-septum progressively anticipate those in the other half, showing how the cyclic method originated; there is often, too, an acceleration of the cyclic period upon the fossular period, since the first cyclic septa may appear before the last fossular.[2]

Recent corals start with six or twelve septa appearing simultaneously, doubtless owing to the fact that, on becoming fixed, the larva already has twelve or more mesenteries.[3] It would be impracticable for the complete appearance of the septa, like the mesenteries, to be pushed back by tachygenesis into the larval period, for the little coral, embarrassed with a cycle of septa, would be too straight laced to swim in comfort. The septa are therefore suppressed until they may conveniently appear, and then they arrive in numbers appropriate to the stage of development attained by the soft parts. The septa, then,

[1] Carruthers, "The Primary Septal Plan of the Rugosa": Ann. Mag. Nat. Hist., ser. VII, vol. xviii, pp. 356–63, 1906.

[2] For example of these points see Duerden, "The Morphology of the Madreporaria.—VI. The Fossula in Rugose Corals": Biol. Bull., vol. ix, pp. 34–7, figs. 7–10, 1905.

[3] e.g. in *Astroides*. Lacaze-Duthiers states: "C'est lorsque le nombre 12 des divisions du polype est atteint . . . que se produisent les dépôts calcaires à peu près en même temps et de même dans toute la zone" ("Développement des Coraillaires, Deuxième Mémoire": Archives de Zoologie expérimentale et générale, vol. ii, p. 328, 1873).

of recent corals already appear in cycles, and other complications mark their periods.

It is easy to see how, by tachygenesis, a period of, for instance, six separately appearing mesenteries (or septa) may be condensed into one of three stages where the septa appear in pairs; and this, in turn, to a single cycle. But tachygenesis generally is shown by the greater condensation of the earlier stages. In the case considered, however, it is the earlier periods that are the least condensed and the later progressively more so. Again, one period may tend to overlap a previous period, as, for instance, the cyclic anticipating the end of the fossular period in Rugosa. This is quite in keeping with the trend of tachygenesis.

Bernard's evolutionary units are themselves the totals formed of units of a former period. So it is in ontogeny. The post-embryonic life-history of a coral involves a radially symmetrical free-swimming stage (very much reduced in recent corals[1]), a stage of bilateral symmetry, shown by the elongate shape of the mouth and by the position and arrangement of the muscle bands of the mesenteries, and a secondarily radial ('biradial') stage in which a radial symmetry tends to be resumed. Similarly, *Zaphrentis* (to take the example of septal development we have already cited) presumably during the free period of its life passed through a stage with no septa, then, on becoming fixed, one in which two, four, and finally six septa are bilaterally arranged, to a stage which has become again radially symmetrical by the equalization in length and spacing of the septa. The fossular period is the anabasis of a second wave of symmetry, bringing the radial up to the acme of bilateral symmetry, and the cyclic period its katabasis down to a secondarily radial symmetry. That is, the first-described periods of septal arrangement themselves become stages in periods of alternating bilateral and radial symmetry.[2] A similar rhythmic process of periods has been demonstrated in the costal development of *Parasmilia*.[3] Thus Bernard's periodic rhythm of units in animal evolution as a whole finds corroboration in the facts of coral development, and, as a point of view, is useful for estimating the relations of various phenomena in phylogenetics.

IV.—Note on the Pollurian–Trewavas Coast Section, Cornwall.

By Upfield Green and C. Davies Sherborn.[4]

ASSUMING that the Lizard Peninsula is a pre-Cambrian complex (Flett), and that the Hornblende Schists of Pollurian have nothing to do with the northern sediments, it will be well to call

[1] Lacaze-Duthiers, op. cit., pl. xiii, fig. 9.

[2] These alternating periods were fully appreciated by Duerden, "The Morphology of the Madreporaria.—V. Septal Sequence": Biol. Bull., vol. vii, pp. 99–101, 1904.

[3] Lang, "Growth-stages in the British species of the Coral genus *Parasmilia*": Proc. Zool. Soc. Lond., 1909, pp. 287–90.

[4] This paper was written in May, 1910. In the previous month the Director of the Geological Survey kindly allowed us to look at the unpublished map, for which favour we undertook to give priority to the Survey. The Survey Memoir having now appeared, we print our views as then written.

attention at first to the extensive folding of the rocks at Pollurian, which gradually loses itself as we pass northward in a series of lengthening S.E.–N.W. folds, finally dying away at Porthleven into more or less horizontal beds as we approach Trewavas. Minor contortion is ignored.

On the north side of Pollurian Cove we see black slates with inclusions of grit and limestone lenticles, the Veryan Beds of the Survey.[1] The limestone lenticles seem rare at Pollurian itself, but occur abundantly in Gunwalloe Cove and in Jangye Ryn, north of Gunwalloe Cove. No fossils have yet been found in these lenticles at this spot, but we found one lenticle in Gunwalloe Cove itself so crushed as to show a cone-in-cone structure[2] which would totally destroy any vestige of organisms, and in this particular these lenticles differ from those found at Porthluney and Porthalla, which contain Silurian fossils. These Veryan Beds form the bulk of the cliff on which stands the Wireless Telegraph Station of Pol Dhu, the base of the Towan Cliffs, the base of Castle Hill, on which Gunwalloe Church is built, and rise again on the south side of Jangye Ryn, the crest of their arch appearing on the shore, while the denudation of the softer overlying and crushed arch of Porthscatho Beds has caused a little S.E.–N.W. cove, as seen on the Ordnance Survey map. The crush at this point appears to have been excessive, for we seem to find pieces of Porthscatho Beds in the top layer of the underlying Veryan. In Jangye Ryn itself the Veryan Beds are seen here and there along the shore with lenticles of bluish-grey limestone full of quartz veins, but the beds gradually die out and are probably last seen in Helzephron Cove.

The Porthscatho Beds first appear in the road leading down to Pol Dhu Cove from the hotel; they form the upper part of the Towan Cliff, Castle Hill, nearly the whole of Jangye Ryn, and the coast to Tremearne Cliffs. They are highly contorted, thrown into sharp folds at Jangye Ryn, and, as we pass north, gradually into longer and longer S.E.–N.W. folds, until at Porthleven they become fairly horizontal and form bold cliffs of grit, breaking up into cubes and tables (much like the South Lizard Hornblende Schists) as one nears Trewavas.

At Gunwalloe Fishing Cove we see a small infold of the Falmouth Slates, and other infolded patches of these slates are met with in the coast section at the base of the cliffs between Gunwalloe Fishing Cove and a point a quarter of a mile south of Looe Bar, while traces can still be found north of Looe Bar infolded among the Upper

[1] The "Mylor-Veryan" of Green (95 Ann. Rep. Roy. Cornwall Geol. Soc., 1908, p. 7). We now recognize the "Mylor" Beds of the Survey to be the upper part of the Porthscatho Series, which, if needing a special name, can be called "Mylor".

[2] Portions of this specimen are now preserved in the Brit. Mus. (Nat. Hist.) and in Jermyn Street Museum. In Pollurian Cove we found a thin band in the Veryan containing discs of limonite after iron pyrites about 12 mm. in diameter; these are comparable to the 'coal-money' found in the North of England (L. J. Spencer). Specimens of this rock also have been given to the above-mentioned museums.

Porthscatho Beds in the first 50 yards of the shore section. Traces of the Falmouth Beds can be found here and there on the fields to the west of the Helston–Lizard road, but the bulk of the debris is of Porthscatho age, and we consider that nearly the whole of the Falmouth Beds have disappeared except for the small patches described as existing on the coast, and the similar patches preserved by infolding among the Porthscatho on the land surface.

The peculiar characteristic rock of the Lower Porthscatho—the massive detrital rock like the well-known Grampound Grit—is seen but once north of Looe Bar (just past the Looe outfall), but this bed may be an ash-bed in the Upper Porthscatho of similar nature to the characteristic rock.

We consider all the 'Mylor' Beds of the Survey as the upper part of the Porthscatho, which in our opinion continues right up to the granite at Trewithick.

There is a very interesting little infold of slate with inclusions at the Looe Bar outfall, associated with the 'ash-bed' mentioned above. This is similar in appearance to some of the Veryan, but the great mass of the Lower Porthscatho which comes over the Veryan does not occur at this point, and one must regard the bed as of merely local stratigraphical interest belonging to the Upper Porthscatho Series.

The Upper Porthscatho consists of thick gritty slates, which weather yellow, bands of gritty slates weathering ashy-grey, and black micaceous sandy slates locally called 'blue-stone'. Quarries are not abundant, and the first sign of 'spotting' in the slates we met with was north of Tremearne Cliff at the 212 feet level on the main road about a third of a mile from the granite of Trewithick.

Having examined this fine coast-section we see no reason to alter the opinion expressed by one of us (Green, Geol. Mag., 1904, p. 401; 95th Ann. Rep. Roy. Cornwall Geol. Soc., 1908, p. 7) that the whole of these beds—Dartmouth, Falmouth, Ladock, Grampound, Manaccan, Mylor, Porthscatho, and Veryan—whatever they may be designated, are of Gedinnian age and have nothing to do with Silurian, Ordovician, or Cambrian rocks, and we consider the stratification of the older Cornish rocks from above downwards to be as follows:—

Gedinnian = Lower Devonian	Falmouth (includes beds called Dartmouth). Porthscatho (includes beds called Mylor, Grampound, Ladock, and Manaccan). Veryan (beds containing lenticular inclusions yielding Ludlow, Wenlock, and Woolhope fossils).
Ordovician.	Quartzites[1] (of Ordovician age with characteristic fossils).

[1] That the Ordovician Quartzites of the Gorran–Veryan–Manaccan anticline once existed in this area is evident from the abundance of the rock in the walls at White Cross and elsewhere. As it is continually being broken up for road-metal, the dotted lines on the old one inch map (Sheet 13, 1839 and 1866) of De la Beche will soon be the main record of its existence in the area.

NOTICES OF MEMOIRS.

I.—The Volcanic Rocks around the Ord Hill of Rhynie, Aberdeenshire.[1] By William Mackie, M.A., M.D.

THESE rocks occupy an area of two-thirds of a mile in length by a quarter of a mile in breadth, of which Ord Hill marks the centre, about half a mile west of the village of Muir of Rhynie, West Aberdeenshire. The group embraces at least three independent lava flows, with associated tuffs and interbedded and overlying sedimentary rocks, and lies on an eroded, eastward-sloping surface of the diorites and gabbros of West Aberdeenshire—rocks which have been considered to represent an early and basic modification of the younger Grampian granite—and are cut off on the east by the boundary fault of the Old Red Sandstone outlier of Rhynie and Kildrummy. A small outlier limited to two or three square yards of surface, and representing a single lava-flow, lies on the edge of the serpentine mass of Cnoc Cailliche about a mile south from the extreme southern end of the main area. The volcanic members of the group consist of grey to greenish coloured rhyolites, showing in places fine vesiculation and beautiful fluidal banding. The usual minerals of such rocks—quartz, orthoclase, muscovite, biotite with at times an occasional augite, are present in an amorphous base. Flow-brecciation is a frequent feature, and evidence of the effect of pressure is not entirely absent. The tuffs consist of fragments of rhyolite rocks—occasionally up to 2 inches in diameter—often rounded and encircled with glassy coronas exhibiting fluidal banding. Broken crystals of quartz and orthoclase, as well as considerable fragments of older tuffs, are also present. The sedimentary rocks of the group consist of very hard siliceous grits which, on microscopic examination, often show the presence of fragments of volcanic rocks of the same general characters as the associated lavas. These fragments are generally larger in size than the accompanying fragments and grains of sedimentary origin. The whole of the group is characterized by the presence of numerous, often very fine, secondary quartz infiltrated veins, and at one part in the sedimentary division these veins make up quite half the bulk of the rock.

Two small masses of biotite granite containing much microcline break through the diorite immediately to the west of the area. With these the volcanic members of the group may or may not have a genetic relationship.

As regards the age of these rocks, it is impossible to arrive at a very definite conclusion. They are manifestly younger than the diorite, but are probably considerably older than the oldest beds of the Old Red Sandstone of the adjoining area. The lavas being throughout of acid type, it is evident that they cannot be correlated with the interbedded andesites of the local rocks of Old Red Sandstone age.

II.—The Millstone Grit of Yorkshire: Some New Evidence as to its Source of Origin.[1] By Albert Gilligan, B.Sc.

MORE than fifty years ago Dr. H. C. Sorby attempted to trace the source whence the material which makes up the Millstone Grit had been derived, by making a collection of pebbles which occur so abundantly in some of the beds. Among these he found some small fragments of mica-schist, quartz-schist, and a few pebbles of undoubted granite. The largest pebble he obtained was about 4 inches in circumference, and of a type resembling a fine-grained syenite of greenstone,

[1] Abstract of paper read before the British Association, Section C (Geology), Dundee, September, 1912.

but too much decomposed to be accurately identified. The pieces of granite were composed of quartz and felspar, suggesting by their appearance derivation from coarse-grained granites. Pebbles of quartz he found to be commonest, and he also described some pieces of white or brownish orthoclase felspar.

The granites he found were quite unlike any with which he was acquainted in the British Isles, being too coarse and much more like those of Scandinavia. Further, the current-bedding, which Dr. Sorby examined over an area of twenty-five square miles, pointed to a drifting from the north-east, and he therefore suggested some south-westward prolongation of an ancient Scandinavia as the source of origin of the material making up the great mass of the Millstone Grit of Yorkshire. Since this early work by Dr. Sorby nothing has been added to our knowledge of the lithology of this, to most people, uninteresting series of rocks. The late Mr. A. Longbottom, B.A., of the Nigerian Survey, collected some very large pebbles from the Middle Grits of Silsden. These have been examined by the author, who has also extended his researches into the other beds of the series in various parts of Yorkshire. Some of the pebbles are of a very large size, one obtained from Netherwood Plantation Quarry, Silsden, measures 10 inches by 8 inches by 3 inches, and is a reddish granitoid rock with large porphyritic felspar. The pebbles show a remarkable assemblage of rocks, igneous, sedimentary, and metamorphic all being represented, but by far the commonest are acid igneous rocks—granites, quartz, and felspar porphyries. Only one specimen of basic igneous rock has been found. The metamorphic rocks are quartz-schist and mica-schist, with a few fragments of gneiss. One of the mica-schist pebbles has been identified by Mr. Barrow as similar to a rock described by him occurring in the Moine Schists of the East Central Highlands. Numerous pebbles of felspar have been examined by the author, and in each case found to be perfectly fresh microcline, the cross-hatching being beautifully clear. Pieces of pegmatite, the constituents being quartz and microcline, are very common in all the beds, but most abundant in the Kinderscout Grit and Rough Rock. Some fragments obtained from the Plompton Grit at Knaresborough proved to be a peculiar silicified oolitic rock, the outlines of the oolitic grains being traced out by small rounded bodies stained red or brown. A few pebbles show undoubted traces of organisms such as sponge spicules, etc.

The heavy minerals of the grit are not numerous, the most plentiful being zircon and garnet. The felspar in the grit, both large and small, are quite fresh when first exposed, and this suggests either disintegration of the parent rock by differences of temperature and rapid transportation, or comparative absence of carbon dioxide in the atmosphere. The author has been much impressed by the many points of similarity existing between the Millstone Grit and the Torridon Sandstone, and is disposed to think that areas of similar rock types were laid under contribution for each.

III.—The Silurian Inlier of Usk.[1] By C. I. Gardiner, M.A., F.G.S.

THE Usk Inlier is roughly oval in shape, measuring about eight miles and a half from north to south and four miles from east to west. It is crossed by an important east and west fault, which divides it into two nearly equal parts. The southern half is composed of two anticlines separated by a fault. The axes of these folds run roughly north and south, and dip southwards. The western anticline is the larger of the two, and shows Wenlock Shales and Limestone and Ludlow Beds; these are all very fossiliferous.

[1] Abstract of paper read before the British Association, Section C (Geology), Dundee, September, 1912.

The anticline has been much broken by faulting, and the limestone is now in twelve separate parts. Careful observations of the dips prove faulting to be a satisfactory explanation of this separation. The Silurians are separated from the Old Red Sandstone to the west, from Littlemill to Trostra, by a fault, but from Trostra to Llandegveth and Graigwith the basement bed of the Old Red Sandstone, a yellow quartzose sandstone, rests with apparent conformity on the Ludlow Beds. The eastern anticline is thinner than the western one. Its lowest bed seen is the Wenlock Limestone of Cwm Dowlais, this being covered by Ludlow Beds, which run south through Llangibby Park. A fault line separates these Ludlows from the Old Red Sandstone to the east. The Wenlock Shale is a brown sandy shale where its lowest beds are seen in the railway cuttings near Bryn, and it becomes more sandy in its higher parts, a definite sandstone occurring close to its summit. The Wenlock Limestone has about 12 feet of massive limestone at its base, largely formed of crinoid fragments, and, above this, irregularly bedded limestone separated by thin shaly partings. Corals are scarce, Brachiopods and Trilobites common. The Ludlow Beds are, for the most part, brown sandy shales, with calcareous nodules or thin calcareous layers, but towards their summit they pass up into sandstones. The northern half of the Inlier is far less simple than the southern in its structure, and is more concealed by drift. Its western boundary is everywhere obscured, but Ludlow Beds are seen here and there dipping towards the Old Red Sandstone not far off the boundary. The central part is composed of Wenlock Shale, and the eastern margin is composed of Ludlow Beds dipping eastwards and faulted against the Old Red Sandstone. The Wenlock Limestone is not met with in this northern half of the Inlier. The simplest explanation of these facts is that the Wenlock Shale is faulted against the Ludlow Beds on both sides. As the Aymestry Limestone is absent from the district, it seems impossible to separate the Ludlow Beds into an upper and lower division, but fossils have been carefully collected in order to see if any horizons can be fixed. The main boundary faults are crossed at several spots by minor east and west faults, which cause small lateral displacements.

REVIEWS.

I.—The Making of the Earth. By Professor J. W. Gregory, F.R.S., D.Sc. 16mo; pp. viii, 256, with 37 text-illustrations. London: Williams & Norgate (Home University Library Series), 1912. Price 1*s.* net.

A HIGH standard has already been attained by the Home University Series, and the little volume now before us will command a place among the best. In the small space at his disposal Professor Gregory tells us the story of our earth from the nebula to the appearance of life, and tells it in a style that has a distinct charm, and within his pages we find accounts of the most important and up-to-date theories concerning our earth. The discussion of the nature of nebulæ leads on quite clearly to the stating of the planetismal hypothesis, with which, further, the evidence of ancient climate is shown to be in agreement. In a clear way, too, Professor Gregory traces the formation of the earth's surface, and in a short chapter shows what earthquakes tell us of the interior of the earth. The geographical distribution of extinct animals and plants is dealt with in an interesting manner in connexion with the inconstancy of oceans and continents, and the discussion of

the distribution of land and sea leads on to a luminous account of the tetrahedral theory of the earth. The chief points in the earth's history through the various geological periods are then dealt with, and the geographical elements are traced in the existing continents and oceans.

Having considered the main stages in the making of the earth, Professor Gregory proceeds to discuss the biosphere, and finishes his sketch with a delightfully speculative chapter on 'Protobion'—the first living being on the earth. At the end of the book is a Bibliography—in this case a particularly useful inclusion. The writer of the geological volume for this series held a peculiar responsibility, and we feel that in the present work Professor Gregory has done much that will help his readers to think geologically.

II.—The Building of the Alps. By T. G. Bonney, Sc.D., F.R.S., Emeritus Professor of Geology, University College, London. 8vo; pp. 384, with 32 plates and 16 text-illustrations. London: T. Fisher Unwin, Adelphi Terrace, 1912. Price 12*s.* 6*d.* net.

IN this handsome volume, printed in large type, light in weight, and admirably illustrated, Professor Bonney gives us a clear exposition of the petrography, general structure, and mode of formation of the great Alpine mountain region, followed by a description of the Glacial phenomena and by remarks on some Alpine topics of modern times. That he has come well-grounded to his task may be judged from the fact that since 1856 he has spent an amount of time upon it equal to nearly three years—in the earlier visits in walking and climbing and observing more particularly the effects of ice-action, in later visits (since 1880) in the investigation of rock-structures in the field, supplemented by home-studies of the materials under the microscope.

In his opening chapter the author deals with the geographical distribution of the rocks, which may be broadly grouped into the crystalline and the obviously sedimentary. The oldest crystalline rocks consist of gneisses and mica-schists, and these are followed by a group of foliated rocks, comprising mica-schists, quartz-schists, crystalline limestones, with serpentine, hornblendic and chloritic rocks. Intrusive in these rocks are coarse granitoid gneisses which often form a central position as the backbones of the higher mountains. The loftier peaks and more prominent ridges are all formed of the great series of crystalline rocks; the sedimentary rocks in only one instance attaining a height of 13,000 feet, in the limestone peak of the Eiger.

Avoiding so far as possible the use of technical terms, the author briefly explains the origin of the crystalline rocks, all of which had undergone great mechanical and chemical changes and assumed a foliated condition prior to the vast movements that led to the elevation of the mountains. He does not deny the possibility that some gneisses may have been produced by the metamorphism of sediments, but he knows of no conclusive instance. He recognizes a great break between the earliest of the sedimentary rocks and the older gneisses and schists, remarking that the former have not advanced in metamorphism beyond the stage of phyllite, or, in other

words, of slate wherein mica is so abundant as to give the rock a peculiar silky lustre.

Ordovician strata are the oldest representatives of the Palæozoic series that have been identified in the Alps, and of these and succeeding formations the author gives brief descriptions. It was not, however, until the end of the Eocene, or quite early in the Oligocene period, that the making of the Alps began, and the process was continued towards the close of the Miocene and into the Pliocene period.

In the course of his chapter on the Materials of the Alps the author discusses the 'difficult question' of certain reported examples of crystalline schists of Silurian, Carboniferous, Triassic, and Jurassic ages. While in certain instances, as he admits, the evidence is inconclusive, yet in others the facts are capable of explanation, and can be attributed to intense folding and overthrust faulting, or to the derivation from older crystalline rocks of mica, garnets, and staurolites. The supposed fossil plants observed in gneiss are now regarded as pseudo-organisms.

In dealing with the great flexures and thrusts which have affected the Alps, we are not surprised to learn that he hesitates to accept all the disturbances "on a scale so gigantic as is demanded by certain enthusiastic advocates of the overthrusting process".

The relations between different types of rock and mountain forms are discussed in an interesting chapter in which the work of Ruskin receives appropriate commendation.[1] The subject too is well illustrated by many of the photographic views and by figures in the text.

Nearly one-third of the volume is occupied by descriptions and discussions concerning the snowfields and glaciers, topics that had been considered by the author in 1865 in a work entitled *Outline Sketches in the High Alps of Dauphiné*, and three years later in *The Alpine Regions of Switzerland and the neighbouring countries*, as well as in separate papers on Cirques, Lakes, and Glacier-Erosion, etc. Here, and also in the descriptions of the rock features, we feel the want of maps, the only important omission among the illustrations in this book.

The making and movement of glaciers and their extension in ancient and modern times are subjects less controversial than those dealing with the sculpturing of the land, the shaping of peaks and valleys, corries or cirques, and the excavation of lake-basins. The author's early conclusions are not modified, namely, "that the work of glaciers is, as a rule, not more than abrasive, and is erosive only under special circumstances." Nevertheless, while the volume is intended to embody the results of his personal observations and researches, he has indicated throughout fairly, and perhaps with more suavity than of old, where different conclusions are held.

There are chapters on Alpine Meteorology, on the Vegetation, and on the Wild Animals of the Alps, and it is interesting to know that the brown bear, wolf, and lynx survive in certain areas. Interesting also is the account of the Alps in relation to Man. It is remarked that the Palæolithic hunter may have wandered into the mountains in pursuit of game, but though he has left a few relics of his presence

[1] See Ruskin, "Shape and Structure of the Alps": GEOL. MAG., 1865, pp. 49 and 193.

in the lowlands, none have occurred, so far as the author knows, within the Alpine margin. Lake dwellings, and the ancient routes and passes traversed in Roman and later times, some of the battles, and the changes undergone in later years, are described; and finally the author relates his personal experiences of fifty years of change, lamenting the injury done by the plunderers of plants, the hooligans, and the advertisement fiend.

Two short appendices contain (1) a few biographical memoranda by the author and a list of his papers on Alpine subjects, and (2) explanatory notes on the full-page illustrations. The index occupies but four pages, and is far too meagre and inconsistent: thus, while the names of Garwood, Ramsay, Sollas, and Penck are given, no mention is made of Fraas, Von Hauer, Heer, Heim, Rothpletz, and some others who are referred to in the text.

III.—Geological Survey of Canada.

THE Summary Report of the Geological Survey Branch of the Department of Mines for 1911 (Ottawa, 1912) contains many matters of general interest.

In the course of his special report the Director, Mr. R. W. Brock, makes some comments on the *difficulty of retaining capable scientists*, and the urgency for securing more rapid promotion and higher salaries for the scientific staff. "The loss of an experienced officer is irreparable; for he has in his work secured a mass of detailed information concerning the districts in which he has been engaged that can never be embodied in a report, but that is of constant value to the Department and the public in answering inquiries concerning particular areas or special problems." The same unfortunate state of affairs prevails on the Geological Survey in Great Britain in reference to the officers who hold the rank of Geologists.

More than forty short reports by various officers are given on the Staff Field work, and it is interesting to learn that Dr. C. W. Walcott, Secretary of the Smithsonian Institution, and formerly Director of the United States Geological Survey, has accepted the honorary position of Collaborator in Geology with special reference to the Cambrian. He contributes a report on the Cambrian of the Kicking Horse Valley, British Columbia, giving sections and lists of fossils from the Burgess Shale of the Stephen formation. (See Dr. Peach's address, Geol. Mag., October, p. 457.)

Mr. A. C. Lawson reports on the Archæan rocks of Rainy Lake, Ontario, and announces the discovery of fossils in the limestones of the Steeprock Series, which rest unconformably on the Keewatin. These fossils (not at present described) are said to be "the oldest well-defined organic remains now known to science".

Other reports deal with the Lower Palæozoic and Devonian rocks, with the igneous rocks of Belœil and Rougemont Mountains in Quebec, with raised beaches and changes of level, and with sundry economic accumulations, including clays, oil, gas, gypsum, coal, graphite, mica, apatite, tungsten-ore (scheelite), silver, cobalt, and copper ores, and the occurrence of minute diamonds and rubies.

IV.—Records of the Geological Survey of India.

FIVE contributions on various subjects appear in the first part of the forty-second volume of the *Records* (1912). Of these, one "On the Survival of a Miocene Oyster in Recent Seas", by Messrs. R. B. Newton & E. A. Smith, contains descriptions of some large oysters found during excavations in a recent deposit in Clive Street, Calcutta. These shells, characterized by their great height and extensive development of the ligamental area, are the same as a form still living in the Sunderbands and elsewhere. Their special interest lies in the fact that they have been proved identical with the Miocene *Ostrea gryphoides* (Schlotheim), generally known by the name *crassissima* of Lamarck. A new variety, *cuttackensis*, a shell less prolonged and having a deeper lower valve, is described, and the paper is illustrated by eight very fine plates. Mr. Cowper Reed's paper on Silurian fossils from Kashmir deals mainly with Brachiopods and Trilobites, which are poorly preserved, only the internal casts or traces of external ornament remaining. These have been determined as almost certainly of Llandovery age, and one new form, *Acidaspis kashmirica*, is described. A list of species is given, the determinations of which are fairly certain since they can be compared with European material in a similar condition. The note on specimens of Blödite from the Salt Range, by Mr. Cyril Fox, contains chemical and crystallographic details and is illustrated by one plate.

The occurrence of gold in the alluvial deposits of Mong Long, Hsipaw State, Northern Shan States, is the subject of a report by Mr. J. C. Brown. The gold occurs in thin laminæ and scales, associated sometimes with 'ultra' nuggets, but results of assays show that the deposits are not worth large-scale exploitation. The paper, which is illustrated by three plates, contains full details of the streams examined, and gives a table showing the distribution and area of the auriferous gravels. The last paper in this part is by Mr. C. S. Middlemiss, and places on record the discovery of large deposits of steatite in the Idar State.

The second part of the same volume contains the General Report of the Survey for 1911, with which is issued an account by Professor A. C. Seward of some dicotyledonous leaves from the Assam Coal Series at Margherita. The specimens were sent to the Survey in the hope of furnishing evidence of the age of the Assam Series. The data are insufficient, however, to warrant any decisive statement, but Professor Seward inclines to the view that they belong to a Tertiary rather than to a Cretaceous flora. The leaves are referred provisionally to the genus '*Phyllites*', and two new forms are described—*P. kamarupensis*, n.sp., an oblong-elliptical leaf, about 20 cm. long, with strong midrib and entire margin, and *Phyllites* sp. (cf. *Nerium* spp.). The leaves have a superficial resemblance to recent species of *Magnolia*, but there is a difference in the secondary veins. Professor Seward takes the opportunity of criticizing the frequent attribution of Cretaceous and Tertiary leaves to *Magnolia*, because in many cases the reasons given are altogether insufficient. He contends that

many determinations of fossil Angiosperms are of little value as botanical records, and thinks that critical revision of existing lists is highly desirable.

The second paper in this part is by Captain Grinlinton, and consists of "Notes on the Poting Glacier, Kumaon Himalaya, June 1911". This glacier was visited in October, 1906, by Messrs. Cotter and Brown, of the Survey, who at that time noted the position of the snout. The main object of the recent examination was to collect any evidence that might be available as to secular change. Results show the snout to be in much the same position as in 1906, and the most striking features observed were in the left lateral moraine, which exhibits signs of great activity. The paper furnishes interesting details as to the condition of the ice, and is illustrated by eight plates, chiefly of diagrams.

V.—South African Geology. By E. H. L. Schwarz, Professor of Geology at the Rhodes University College, Grahamstown, South Africa. 8vo; pp. vi, 200, with 54 figures. London: Blackie and Son, 1912. Price 3*s.* 6*d.* net.

PROFESSOR SCHWARZ tells us in the preface to this little book how in one of his lectures a roar of laughter greeted a remark to the effect that in the desert springs have no brooks. The humorous aspect is apparent after the explanation that "the only brooks that the South African student knows of are the Dutch equivalent for trousers". The Professor was well acquainted with the difficulties with geological nomenclature experienced by the South African student, but this episode decided that there should be no further delay in the production of a small volume dealing with geology from the South African standpoint. We can quite comprehend that what *not* to include would be a troublesome consideration in the preparation of a work of this kind, but another, the author tells us, was that the book had to be orthodox! We do not think, however, that he errs very much in including an account of the planetismal hypothesis.

The book is divided into four sections, dealing with descriptive, dynamic, tectonic, and stratigraphical geology, the last occupying nearly one-half of the book. The account of volcanoes is good, and we are glad to see reference to the results of Brun's investigations. Throughout the book Professor Schwarz considers facts in relation to their causes, and aims at giving "some insight into the processes of geological reasoning", but in some places his diction is loose. Thus, the statement (p. 82) that "the cause of volcanic action is undergoing revision" evidently is not expressive of the author's true meaning. Seven pages of woodcuts (of Bokkeveld, Karroo, Uitenhage, Stormberg, and Pondoland fossils) and two restorations of reptiles illustrate the palæontology of the various areas described in the stratigraphical section. The legends of some of the woodcuts, we note, require revision, *Tancredia* for *Meyeria* and *Exogya* for *Exogyra* (both on p. 168) being obvious misprints. It would have been better, moreover, to append in every case to the names of the

fossil plants figured some indication of the particular structure represented. Are we to regard the omission of an index as an indication that the publisher intends the book to be learnt by heart?

VI.—The Water Supply of Surrey, from Underground Sources, with Records of Sinkings and Borings. By William Whitaker, B.A., F.R.S.; with contributions on the Rainfall by H. R. Mill, LL.D. 8vo; pp. v, 352, with rainfall map; cloth. London, 1912. Price 7*s*.

SINCE his retirement, some years ago, from the public service, Mr. Whitaker has not ceased to devote much time in the interests of the Geological Survey, and his volume of the *Water Supply of Kent* (noticed in the Geological Magazine for 1909, p. 180) has now been followed by a volume nearly as extensive and quite as exhaustive on the *Water Supply of Surrey*.

The old county division is retained, consequently the records include those relating to the boroughs of Wandsworth, Battersea, Lambeth, Camberwell, Southwark, and Bermondsey, that are now part of the county of London. The geological formations which are water-bearing comprise the Drift gravels and sands, Bagshot Beds, Blackheath Beds, Thanet Sand, Chalk, Upper and Lower Greensand, and Hastings Beds.

Accounts are given of the various springs which issue from these formations, including the mineral waters, of which those of Epsom are the most noted. A short description follows of swallow-holes, and full particulars are then given of the intermittent streams or bournes. The Mole has always attracted much attention. When the stream is full, as in winter-time, some of the water finds its way into swallow-holes in the Chalk by the side of the stream; in dry times, as in summer, the stream enters the Chalk tract from the south; but as the underground water-level sinks below the level of the river-channel in places, the stream water is largely absorbed, and the channel becomes dry here and there with occasional pools. Records of the famous Croydon Bourne are given mainly on the authority of Mr. Baldwin Latham, supplemented by personal and other observations.

Remarks are made on the effect of pumping on wells and springs, and on the subject of contamination. The public and private supplies of water taken from springs are few, nearly all the water being obtained from wells and borings, except in the north-eastern part of the county, which is supplied by the Metropolitan Water Board.

Of the wells and borings the deepest is at Ottershaw Park, Chertsey. It was carried through Bracklesham Beds to the base of the Gault, and Lower Greensand was reached at a depth of 1,556 feet. From this formation water overflowed at the surface at the rate of 132,000 gallons a day. The occurrence of the Lower Greensand below ground at this locality strengthens the view of the author that the formation on this westerly side of the London Basin may be continuous to the northern outcrop.

Details of wells and borings occupy 185 pages (including some addenda). Numerous analyses of waters are given, and in a section

entitled Miscellaneous there are remarks on the relation of ground-water to disease, mainly by Mr. Baldwin Latham; notes on gases in wells and well-waters; and statements on the Law of Underground Water with especial reference to the county. A bibliography and excellent index complete this important and useful work.

VII.—Oil-finding: An Introduction to the Geological Study of Petroleum. By E. H. Cunningham Craig, B.A., F.G.S.; with an introduction by Sir Boverton Redwood, Bart. pp. xi + 195. London: Edward Arnold, 1912. Price 8*s.* 6*d.* net.

OWING to the greatly increased employment of petroleum of late years, its production and mode of occurrence in the earth's crust have naturally attracted considerable attention. Mr. Cunningham Craig's book should, therefore, prove of interest to a wide circle of readers. The author very properly points out the erroneousness of the supposition that the petroleum industry can be practically considered apart from scientific considerations, and that the finding of petroleum in a given area ought not now to be a matter of mere speculation. His treatment of the subject is bold, and he expresses his opinions strongly and clearly; and, although these may not be generally accepted, they may at least have the good effect of stimulating discussion.

Unlike previous writers, Mr. Cunningham Craig regards the origin of petroleum as the question of vital importance, and to which all others must be subsidiary. The arrangement of the book is in keeping with this standpoint; the discussions throughout are logical, and the appeal to facts frequent; but as regards these facts much must depend on their selection. Of the various theories that have been advanced to account for the origin of petroleum, the author is a special pleader for that which ascribes it to terrestrial vegetation. He admits that the frequent association of salt and brine with petroleum is difficult of explanation in the face of his theory; still, with respect to this point he thinks that future research will produce results of the greatest importance. His present opinion, however, is that the association is accidental. Separate chapters are devoted to processes of formation, migration, subterranean storage, and geological structure, and the author emphasizes the importance of the study of lateral variation, by which alone can oil-forming and oil-bearing conditions be recognized. Useful hints as to field and indoor work are given in the last two chapters. These, although intended for beginners, might well be consulted by persons of more experience. The book is illustrated by thirteen plates of photographs, chiefly of scenes in Burma and Persia, and is furnished with a copious index.

VIII.—The Sedimentary Deposition of Oil. By Murray Stewart, D.Sc., F.G.S.

THE author of this pamphlet, which is reprinted from the Records of the Geological Survey of India, vol. xl, pt. iv, pp. 320–33, 1910, is one of the comparatively few British geologists who have

had much opportunity of studying the occurrence of oil in the field. He here puts forward an interesting theory concerning the origin of oil.

Commencing with a statement in favour of organic origin, he proceeds to discuss the well-known but unexplained property possessed by clay whereby it is able to absorb oil and hold it under water. Several interesting quantitative experiments were performed, and it was found on shaking up clay and water and adding oil that 66 grammes of clay sediment took down with it on settling all the oil up to the amount of 14 c.c. The clay and oil used were both from the Yenangyoung Oilfield of Burma. When an American oil, much lighter and of much less viscosity, was used a still greater absorption occurred.

Microscopic examination of the oily sediment showed that the oil was not imprisoned as oily films upon the grains, but "was merely mechanically mixed with the sediment, and that it was the small size of the shale particles that made it impossible for the globules of oil to escape between them and so reach the surface". The limit to the quantity of oil which can be held is reached "when the percentage of oil globules in the whole mass of particles is so great that the oil globules are almost in contact". This varies with the size of the globules, which in turn is dependent on the viscosity.

"The deposition of oil is purely a matter of gravitation." The oil becomes mechanically mixed with the sediment in the form of globules. The oil is unable to separate out, because it is not miscible with the wet mud particles, which part them and prevent them from coalescing.

"The mixture of sediment and oil, being still of higher specific gravity than the water, falls to the bottom and is deposited as a sedimentary deposit."

We think Dr. Stewart's explanation of the absorption of oil far preferable to those put forward hitherto wherein some mysterious affinity between oil and clay was assumed; but we think that the physicists could throw still further light on the problem, and that the question of whether shale particles would be coated by oil under water, or whether globules of oil would be coated with specks of shale, or whether the globules become merely mechanically imprisoned, may be dependent upon the various surface tensions between the liquids and solid concerned. Some readers probably will consider that flowing water would have to be unusually highly charged with mud for oil to be carried down in the manner described.

In the later pages of the pamphlet it is suggested that in oil-bearing formations "oil is of sedimentary origin and is not a secondary product in deposits"; the decomposition of the organic matter (mainly vegetable) has occurred in closed lagoons and swamps "under bacterial action, the oils so formed rising to the surface and forming a layer of oil". At times the oil would find its way into the rivers and ultimately would be deposited in the manner described above. Later, as other strata accumulated above, a certain pressure would be reached for each bed of clay, when the oil would be squeezed out and would find its way into the seam of sand lying next

above. The author considers his theory more satisfactory than others, because it "does not require any supposed removal of either nitrogenous matter or the fibrous tissues of plants, neither does it require the assumption of bacterial action deep underground in the presence of salt water".

We think that some field evidence is desirable to support this interesting idea. The present writer has seen something of tropical lagoons in the quest of oil, but he has not seen oil films on any of them (except where oil rock crops out beneath). If such a phenomenon does occur it certainly is either invisible or unusual. The author is careful, however, to point out that he does not wish to apply his explanation of the formation of oil to every case.

T. O. B.

IX.—Cotteswold Naturalists' Field Club.

WE have before us part iii of vol. xvii of the Proceedings of this Club. It contains records of sundry excursions, including one to Cirencester (with a view of the Royal Agricultural College), and another to Brecon (with views of the Brecon Beacons, Llangorse Lake, etc.). The original articles are mainly geological. The indefatigable secretary, Mr. L. Richardson, contributes a "Memoir explanatory of a map of part of Cheltenham and neighbourhood, showing the distribution of the sand, gravel, and clay". The map is a colour-printed geological edition of Sheet 26 N.E. (Ordnance six inch map). The amount of detail is not great, but the map clearly shows, by means of six tablets and colours, the distribution at the surface of Lower and Middle Lias clays, and Drift gravel, sand, and bog. The reproduction of the map must have been costly, but it should be of practical service. Details of the strata and their fossils are given in the memoir, the materials having "been acquired little by little over a period of at least ten years". There is an analysis of Lower Lias clay, also notes on economic uses of the deposits, their soils, and supplies of water; and there are illustrations of brick-works, clay and sand-pits. Dr. J. H. Garrett supplies an appendix "On the Local Waters of the Town of Cheltenham". The mineral waters are of especial interest, as coming from the Liassic clays, and from the fact of "the quality of the yield of no two wells being alike, but often quite distinct and different, though the wells be only a short distance apart".

Dr. E. A. Newell Arber is author of a paper on "The Fossil Plants of the Forest of Dean Coalfield", illustrated by three plates. The floras of the productive strata all belong to the Upper Coal-measures; and they include forty-four species, all known to occur elsewhere in Britain. The author observes that "The Forest of Dean is not an outlier of the South Wales coal-field, as has often been supposed. It is more closely related to the Radstock and Bristol coal-fields. There are no equivalents in the Forest of Dean of the Middle Coal-measures (White Ash Series) or Transition Coal-measures (Pennant Grit) of South Wales, and the massive Forest of Dean Stone belongs to a higher horizon than the Pennant Grit, with which

it has been often correlated". These views appear revolutionary, but we have been prepared by Dr. T. F. Sibly (GEOL. MAG., 1912, p. 417) for the new interpretation of the structure of the district.

Among other articles is one by Mr. William Bellows on "The Island of Jan Mayen"; one by Mr. Richardson on "The Water Supply of the City of Gloucester"; and one on "The Lower Severn Plain during the Glacial Epoch", by Mr. Joseph W. Gray. In this last paper the author concludes that the deposits "suggest a partial derivation from moraines left by ice-sheets that approached the district on the north and east. Other parts may be remnants of Tertiary river gravels". He further remarks that "Although there may have been an extension of the Severn Estuary as far north as Worcester, there is no evidence of a great Post-Cretaceous submergence of the whole of the Plain".

X.—PREHISTORIC SOCIETY OF EAST ANGLIA.

IN the GEOLOGICAL MAGAZINE for November, 1911 (p. 522), we drew attention to the first part of the Proceedings of this Society. The second part, for 1910–12, has just been issued (H. K. Lewis, 136 Gower Street, W.C., price 3*s*. 6*d*. net). It contains abundant material concerning flints variously shaped, some by nature, most of them regarded as 'artifacts' or not manufactured by nature. The several papers are illustrated by no less than thirty-one plates, some of undisputed Palæolithic and Neolithic implements, scrapers, flakes, and cores, others of the partially chipped or unchipped flints that may have been found serviceable by man or "some intelligent ape-like progenitor".

Dr. W. Allen Sturge writes on "The Patina of Flint Implements", Mr. J. Reid Moir on "The Natural Fracture of Flint and its bearing upon Rudimentary Flint Implements", and Mr. F. N. Haward on "The Chipping of Flints by Natural Agencies". The views expressed are not all favourable to the great antiquity of man, nor to the evidence of his handiwork on some of the ruder types of so-called implements. Considering that there is doubt about the presence of man in Pliocene times, it would be preferable not to use so definite a title as that on "Implements of Sub-Crag Man in Norfolk", by Mr. W. G. Clarke. "Sub-Crag Implements" would be better, as it would allow of the agency of an anthropoid animal. It is indeed remarked by Mr. Moir that "The biologists have no evidence as to when Man first appeared on this earth, and in my opinion are quite absurd in drawing conclusions regarding him from the other mammalia". This is not a philosophical statement. Mr. Haward, in discussing the "interesting and problematic chipped stones called Eoliths", concludes "that the vast majority of these meaningless chipped flints are the result of Nature's work and not Man's". A full account of "The Occurrence of a Human Skeleton in a Glacial Deposit at Ipswich" is given by Mr. Moir, and one of the remarkable points mentioned is that "the skeleton was lying partly embedded in glacial sand and partly in boulder-clay". If true, this seems inexplicable. The "boulder-clay", however,

was a weathered and decalcified brown loam, and the geologists who have given testimony could not express opinions whether or not there had been evidence of interment.

In Dr. A. Keith's "Description of the Ipswich Skeleton" (with illustrations) he refers to the Heidelberg jaw and the fossil man of Java, observing that "the Ipswich man differed profoundly from both of these, and in every point in which he differs from them he approaches modern man". Further and more precise evidence is required, and although we agree that many rude pre-Palæolithic or Eolithic implements may have been utilized by man in early Pleistocene times, we have yet to be convinced that he lived in Britain during the Pliocene period.

NOTE.—Several references have already been made to the Ipswich skeleton: see article by G. Salter, GEOL. MAG., April, 1912, pp. 164–9; letter by Professor T. McKenny Hughes, F.R.S., April, pp. 187–8; letter by J. Reid Moir, May, pp. 239–40; Report Royal Anthropological Institute, June, pp. 287–8.

XI.—BRIEF NOTICES.

1. UNITED STATES GEOLOGICAL SURVEY.—From this institution we have received a list (pp. 116, with good index, 1912) of all the serial publications of the Survey, including Annual Reports, Monographs, Professional Papers, Bulletins, Water-supply and Irrigation Papers, Mineral Resources, Topographic Atlas (folios and separate sheets), and Geological Atlas (folios). The list is complete to date, except as regards the particulars of the topographic maps and authors of both memoirs and maps are recorded.

2. GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.—The Annual Progress Report of this Survey for 1911 (Perth, 1912) by the Government Geologist, Mr. A. Gibb Maitland, contains brief records of the work done in the field, office, and laboratory. It is noted that samples of fergusonite (tantalate of yttrium) from Cooglegong prove to be of economic importance, and may lead to an industry for the preparation of tantalum salts. Since the new radio-active mineral, pilbarite, was discovered at Wodgina, two further minerals containing uranium, radium, and thorium have been found in the same lode. These may be identified with mackintoshite and thorogummite, previously recorded from Texas. All three minerals are of high commercial value.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

November 6, 1912.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "A Contribution to our Knowledge of Wealden Floras, with Special Reference to a Collection of Plants from Sussex." By Albert Charles Seward, M.A., F.R.S., F.L.S., F.G.S., Professor of Botany in Cambridge University.

In this paper an account is given of specimens of Wealden plants

from the Sussex coast, for the most part from the neighbourhood of Fairlight, acquired by the British Museum since 1895, the date of publication of the second part of the Wealden Flora (British Museum Catalogue). The majority of the fossils have been presented to the National Collection by Father Félix Pelletier and Father Teilhard de Chardin, by whom they were collected, and who worked in association with Mr. Charles Dawson, F.S.A., F.G.S.; the remainder form part of the Rufford Collection. Fresh information is given in regard to several previously recorded species, and the following new types are described: A new species of *Lycopodites* (a lycopodiaceous plant with the habit of a *Selaginella*); a new species of *Selaginellites*, which affords evidence of heterospory; a new species of *Hausmannia*, founded on several well-preserved fronds; a new genus and species represented by incomplete fertile pinnæ with well-preserved spores very similar to those of recent Schizæaceæ; a new genus and species of fern founded on fertile pinnæ; *Aphlebia* sp.; a new species of *Dichopteris*; *Ctenis* sp.; a new species of *Conites*; *Pinites* sp., cf. *P. dunkeri*, Carr. Additional information is given in regard to the following species: *Sagenopteris mantelli* (Dunk.), *Matonidium gœpperti* (Ett.), *Ruffordia gœpperti* (Dunk.), *Cladophlebis browniana* (Dunk.), *Williamsonia carruthersi*, Sew. (?), *Otozamites klipsteini* (Dunk.), *Eurycycadolepis* sp., *Araucarites pippingfordensis*, Ung., *Pinites solmsi*, Sew., and *Sphenolepidium kurrianum* (Dunk.).

The concluding section deals with Wealden floras generally, and some account is given of the geographical distribution of the better-known types. It is pointed out that, while there is a very close similarity between the Wealden flora of England and the corresponding floras in Eastern and Western North America, the number of cosmopolitan types is less than in the case of the Middle Jurassic floras.

2. "Notes on the Discovery of Fossiliferous Old Red Sandstone in a Boring at Southall, near Ealing." By Ernest Proctor, A.R.C.S. (Communicated by Professor W. W. Watts, Sc.D., F.R.S., V.P.G.S.) With a Note on the Fish-remains, by Dr. A. Smith Woodward, LL.D., F.R.S., Sec.G.S.

The boring described in this paper is situated at Southall, and was made for the purpose of obtaining water from the Lower Greensand. For this purpose, however, the boring was a complete failure, as it passed directly from the Gault into Palæozoic rocks. The older rocks were met with at a depth of 1,130 feet, and continued with slight variation to a depth of 1,261 feet, the lower limit of the borehole. For the most part they were red and green mottled clays and sandstones, with occasional bands of fine conglomerate.

The fossils were yielded by definite bands, which varied from 1 inch to an eighth of an inch in thickness; they consisted mainly of scales and teeth of *Holoptychius* and plates of *Bothriolepis*, both characteristic genera of the Old Red Sandstone.

The paper concludes with a brief description of the fish-remains, which, although fragmentary, are sufficient to indicate the Upper Devonian or Upper Old Red Sandstone age of the rocks in which they were discovered.

CORRESPONDENCE.

PROFESSOR BONNEY AND THE LATE COLONEL GEORGE GREENWOOD.[1]

SIR,—In justice to the memory of one who has been long departed, but a former writer in the GEOLOGICAL MAGAZINE, I trust you will allow me to enter a strong protest in your pages against the manner in which Professor Bonney has treated the work of my uncle, the late Colonel George Greenwood, in the book he has recently published under the title of *The Work of Rain and Rivers*, one of the Cambridge Manuals of Science and Literature.

Colonel George Greenwood published his work, *Rain and Rivers*, in 1857, at a time when geological opinion had by no means emancipated itself from the doctrines and dogmas of the *cataclysmic* and *catastrophic* school. He was one of the very first to argue in support of the "doctrine of continuity", maintaining that the present aspect of the globe is due to causes still at work, and which have been acting for an immeasurable period of time. He was, in fact, a pioneer of the doctrine of "evolution in the organic world". It was, therefore, with great appropriateness and entire justice that the late Mr. Mackintosh styled him "the father of modern sub-aerialism" (GEOL. MAG., 1876, p. 572).

I maintain, therefore, that Colonel George Greenwood is entitled to very honourable mention in the history of geological thought. But how is he treated by Professor Bonney? The Professor first damns him with faint praise, and then dismisses him with a quotation from some unknown 'reviewer' in the GEOLOGICAL MAGAZINE of 1867 (p. 412). Professor Bonney, on p. 132, further says: "It was not until 1862 that the work of rivers in the excavation of valleys was placed beyond question in our own country. For this we are indebted to . . . J. B. Jukes . . ." I should be the last to underrate the debt which is owing to the memory of Mr. Jukes, but what did Professor Jukes say himself in 1863 of Colonel Greenwood's book? He alludes to it as "an excellent little work called *Rain and Rivers* . . . in which the atmospheric origin of all river valleys is advocated in the clearest and most convincing style".

In view of all this (and much more evidence to the same effect could be adduced), I venture to say that Professor Bonney does very great injustice to the memory of the author of a most clearly reasoned and original work. I can only appeal to you, sir, in the interest of historical accuracy, to give this letter a place in the GEOLOGICAL MAGAZINE, and to Professor Bonney to eliminate a passage as ungenerous as it is unjust from the second edition of his Manual. Meanwhile, if this letter could but induce some geological students of to-day to read for themselves the pages of *Rain and Rivers*, they will, I am confident, recognize the justice of the claim which I make on behalf of a remarkable book.

GEORGE GREENWOOD.

HOUSE OF COMMONS.
November 19.

[1] [Owing to want of space it has been found necessary to greatly abridge Mr. Greenwood's letter.—ED. GEOL. MAG.]

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